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THESIS

RELIABILITY IMPROVEMENT WARRANTIES:
GOVERNMENT BENEFITS, CONTRACTOR RISKS

by

Roland Franz Habicht

December 1976

Thesis Advisor: R. R. Judson

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(20. ABSTRACT Continued)

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Reliability Improvement Warranties:
Government Benefits, Contractor Risks

by

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requirements for the degree of

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ABSTRACT

Reliability Improvement Warranties illustrate a new contractual technique for improving reliability by providing a strong monetary incentive to the contractor. This incentive, however, also places additional monetary risk on the contractor. Industry has expressed mounting concerns over this risk. This thesis contains an examination of the relationship between government benefits and contractor risk. Existing and proposed RIW contracts are evaluated in regard to the type of equipment under warranty, the use of exclusions, penalties for non-compliance, and RIW price. The results of the analysis illustrate how RIW is being used by the government.

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I. INTRODUCTION

The need to improve combat effectiveness and reduce skyrocketing equipment support costs has been recognized as a major problem by the Department of Defense. The problem exists because performances and acquisition costs have become the driving factors behind the procurement of new weapon systems. Reliability requirements have not been integrated with the design effort and usually have been designated for demonstration only at the conclusion of full scale development. The demonstration was normally conducted in a laboratory environment that had little resemblance to the actual environment the equipment was faced with in the field. Contractors viewed this demonstration as the only reliability hurdle their equipment had to pass and were strongly motivated to design to the benign test environment. Because the government was intimately involved with the contractor during the design effort and frequently initiated design changes, responsibility for reliability became diffused. Original reliability standards were not enforced and sometimes were lowered when it became apparent they could not be met. Contractors, who have been capable of designing and producing reliable hardware, did not do so because their rewards were realized from producing a high performance system for the least possible cost and not from the production of reliable equipment.

A. OBJECTIVE OF RIW

In a joint memorandum dated 14 August 1974, the Director, Defense Research and Engineering and the Assistant Secretary of Defense (I&L) stated that the objective of RIW is:

> "... to motivate and provide an incentive to contractors to design and produce equipment which will have low failure rates and low repair costs during field/operational use. This technique attempts, through the use of contractual agreements (which extend for several years after government acceptance of the equipment) to provide an incentive for contractors to improve the reliability of their equipment and to reduce repair costs in order to maximize their profits. Thus the intent of the RIW contracting technique is to realize improved operational reliability and maintainability of DOD systems and equipments for each additional dollar that the contractor earns. For these reasons, a RIW is not a maintenance contract and should not be used for this purpose."

The proper application of RIW should therefore result in the acquisition of equipment that has been designed and produced to have a low initial failure rate in the field. This initial failure rate will be lowered even further during the warranty period due to the incentive the RIW provides the contractor. The maximum benefits from RIW are therefore expected to be realized during the initial years of an equipment deployment. At the end of the warranty period the government can either extend the warranty or assume its own organic maintenance. It is anticipated that at the end of the warranty period the reliability of the equipment will

have grown to a point where the number and costs of repairs are much lower than if the government had not applied the warranty and assumed its own organic maintenance when the equipment was initially introduced.

B. RIW DEFINITION

A Reliability Improvement Warranty (RIW) is a fixed price commitment that obligates the contractor to repair or replace, within a specified time, all warranted equipment that fails during the period of coverage. Ideally, RIW motivates the contractor to increase reliability in order to decrease his repair warranty costs and maximize his profits. In a pure RIW contract the contractor is not obligated to provide equipment that demonstrates a specified Mean Time Between Failure (MTBF). Instead the price of a warranty is calculated using an "expected" MTBF. If the field MTBF falls below this level the contractor will not realize a profit since the increased number of failures increase his repair costs. An increase in MTBF above the "expected" level will, in the same manner, decrease his repair costs and increase his profit. The contractor is therefore motivated to increase the MTBF of the equipment as much as possible if the realized savings from decreased repair costs are greater than the cost of improving the MTBF.

A RIW may also be used in association with a MTBF guarantee as part of the warranty agreement. This arrangement

requires the contractor to guarantee that a stated MTBF will be experienced by the equipment in the field. Failure to meet this guarantee level requires the contractor to institute corrective action and provide additional spares to the government until the MTBF improves.

In any case the RIW provisions should be established as a separate line item in the contract so that the cost of the warranty can be evaluated. In the case of RIW with a MTBF guarantee the additional cost of the MTBF guarantee option should also be established as a separate line item so that the additional protection of the guarantee also may be evaluated for cost effectiveness.

Although RIW can be used to improve the reliability of equipment already in the field by applying the warranty to an equipment overhaul contract, the major benefits arise from using the concept in the initial production contract for new equipment.

C. RIW AND THE SYSTEM LIFE CYCLE

Although application of an RIW is associated with a production contract, it is important that the concept be considered early in an equipment's life cycle since a decision to use RIW will affect the configuration and design as well as the planning needed to obtain and support the warranted item. The interface of warranty activities with the acquisition cycle is shown in Figure 1.

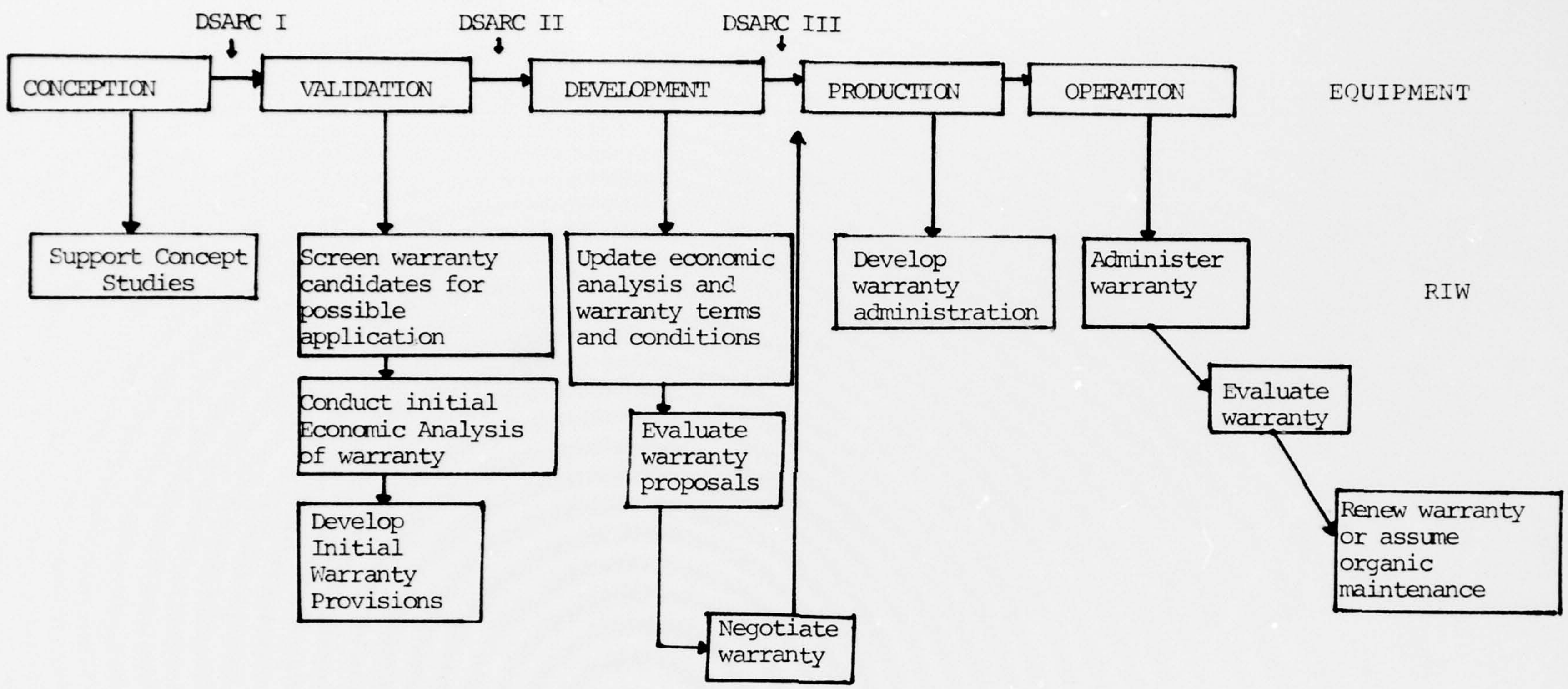

Figure 1. RIW and the System Life Cycle for New Equipment

During the conceptual stage studies are usually made that include the relationship of reliability, maintainability and expected life cycle cost. RIW as well as other methods should be considered as a means of achieving goals and controlling costs. In some cases a more traditional approach of specifying a design MTBF will be more appropriate. This is especially true for equipments that do not meet RIW application criteria (Table 1). Another option is to compare Target Logistic Support cost with Measured Logistic Support Cost, a method that will be discussed in the F-16 contract between the U.S. Air Force and General Dynamics. The Development Concept Paper[1] (DCP) should include instructions or requirements for the use of such control techniques.

During the Validation Phase, consideration is given to required reliability levels and their impact on system support. Consideration should also be given to methods that can be used to achieve reliability levels. At this point, equipment candidates for RIW should be screened to determine if application criteria are met. Assuming the results of this initial screening are positive, an economic analysis should be carried out on each candidate to determine the

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[1]The DCP is a coordinated, management document which serves as the vehicle for the Secretary of Defense's decision on major development programs; the record of primary program information, decision rationale, and decision review thresholds; and the instrument to effect implementation of these decisions.

TABLE 1

RIW APPLICATION CRITERIA

compiled from criteria stated by OSD(I&L), Army Material Command, and Naval Air Systems Command

1. Warranty can be obtained at price commensurate with the contemplated value of the warranty work to be accomplished.
2. Moderate to high initial support costs are involved.
3. Unit is generally self contained, immune from induced failures from outside units, and has readily identifiable failure characteristics.
4. Unit is readily transportable to permit return to vendor's plant or contractor can provide field service for it.
5. Expected operating time and use environment known.
6. Can be contracted for on a fixed price basis.
7. Contract can be structured for a warranty period of several years so contractor has time to identify and analyze failures to permit reliability and maintainability improvements.
8. Unit has potential for reliability growth and reduction in repair costs.
9. Potential contractors indicate cooperative attitude toward RIW acceptance and evaluation of effectiveness.
10. Enough units are to be procured to make RIW cost effective.
11. Unit is configured to discourage unauthorized field repair, preferably sealed and capable of containing elapsed time indicator.
12. Reasonable assurance of high use of item.
13. Unit permits contractor to effect no cost ECP's subsequent to government approval.
14. Failure data and operational use data can be furnished contractor and updated periodically through life of warranty.
15. Field reliability, costs to support, and reliability growth are reasonably predictable.
16. Terms of RIW can be tailored so that risks and rewards to government and industry are acceptable.
17. Spare part requirements are difficult to predict.
18. Cost of the RIW can be separately priced.
19. Multiple-year procurement (competitive or sole source) is feasible.
20. Unit is equipped with an elapsed time indicator; otherwise, the warranty must be based on calendar time, or some other means of determining usage.

economic feasibility of the warranty and the desired warranty period. Initial warranty provisions should then be determined. In order to communicate to the contractor the intention that a warranty provision is being considered, the Request for Proposal (RFP) for the Full-Scale Development Phase should contain a sample warranty provision intended for use in the production contract. The RFP should also ask respondents to discuss their understanding of the warranty provision and how they would operate under the warranty program.

During the Development Phase, initial economic feasibility studies and warranty provisions should be updated to reflect program and equipment changes. At the end of this phase warranty provisions are incorporated into the production RFP. The warranty proposals provided by the responding contractors are then evaluated and a final decision made regarding the intention to use RIW. If the decision is made to apply RIW, the source selection activity, uses the contractor's warranty proposal information as an integral part of its evaluation criteria.

During the Production Phase a planto administer the warranty must be developed. The plan should include provisions for:

1. How the flow of the warranted equipment from the service's logistic management system will interface with the contractor.

2. User indoctrination for processing the warrantied equipment.

3. Requirements for receiving inspection, and documentation at the contractor plant.

4. Requirements for the contractors and government data system.

5. Offices responsible for the contract administration should be identified and be supplied proper data for administering the warranty.

6. Methods for expeditious processing of Engineering Change Proposals[2] (ECP's) must be established.

7. If required, the contractor's repair and storage facilities should be reviewed.

8. Technical data review to insure that contractor has placed notice of the warranty and warranty procedures in the applicable technical publication.

9. Review of Warranty Marking and Seals.

During the Operational Phase the warranty should be monitored to insure that no problems develop in the overall logistic flow of the equipment. If problems develop,

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[2] An ECP is a proposal to make an alteration in the physical or functional characteristics of an item delivered, to be delivered, or under development, after establishment of such characteristics.

adjustments to the original warranty procedures may be required, however, if there is a change in the RIW contract it must be renegotiated and additional cost may be incurred. Before the end of the warranty period an evaluation should be conducted to determine if the warranty should be extended. The original terms and conditions of the RIW should be reviewed to determine if they are still applicable. A new warranty agreement must be negotiated with the contractor and a decision made to either extend the warranty or convert to organic maintenance. If a decision is made to convert to organic maintenance the conversion should be monitored to insure that test equipment, technical data/publications, spares, training, and maintenance facilities are provided to the government within the terms of the initial agreement.

A RIW provision for an equipment overhaul contract must pass through most of the same procedures, however, since the equipment is already in the field these actions are taken during the operation phase (Figure 2) and do not have an effect on equipment design.

D. POTENTIAL BENEFITS FROM RIW

Potential benefits to both the government and the contractor are anticipated from the use of RIW.

1. Benefits to the Government.

a. Incentives and responsibility for field reliability are assigned to the contractor.

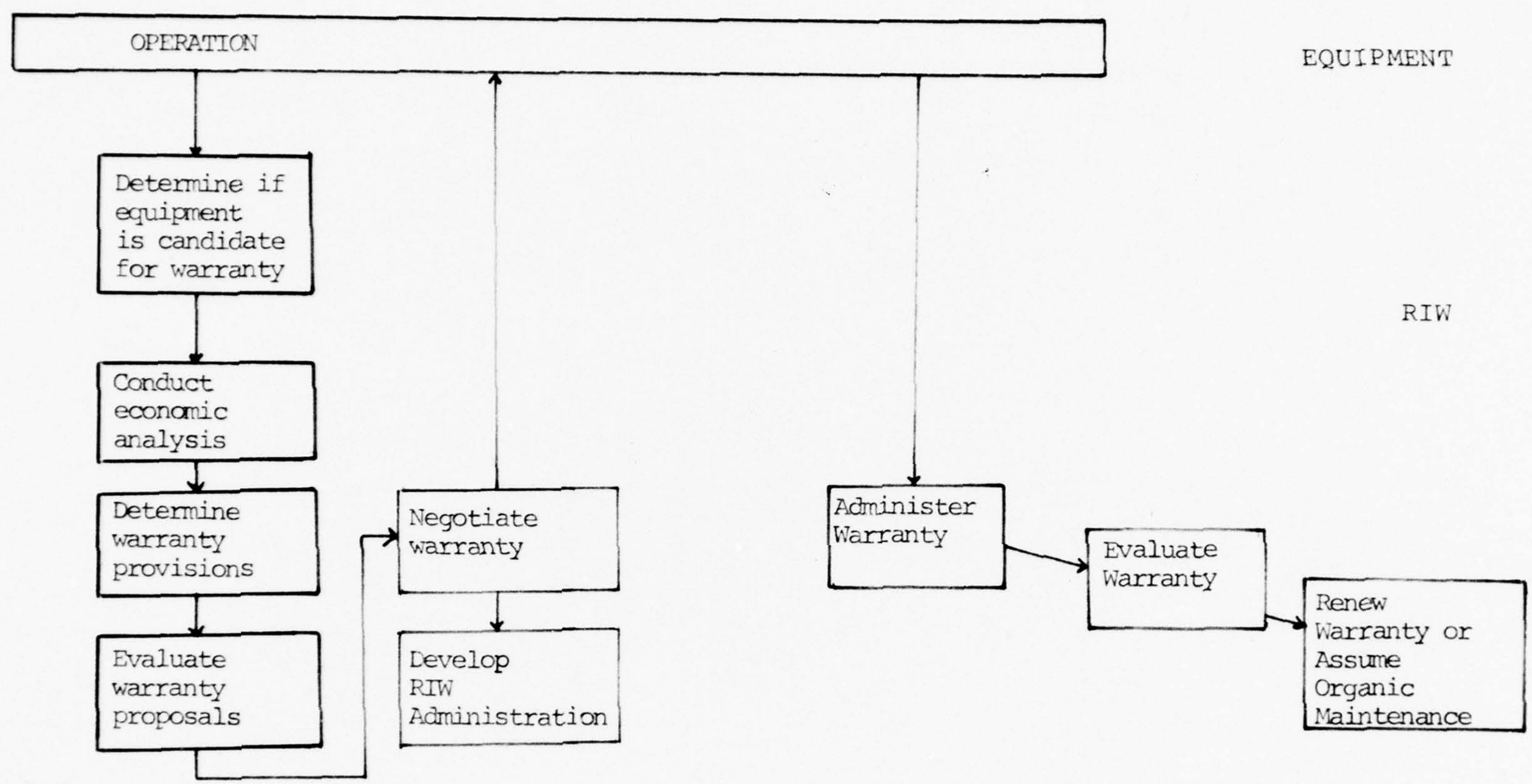

Figure 2. RIW Application to Equipment Already Deployed

b. Greater emphasis placed on Life Cycle Cost.[3]

c. Contractor is responsible for keeping all units up to the same configuration.

d. There is an increased incentive for the contractor to introduce design/production changes that will increase the MTBF of the equipment and result in reliability growth.

e. An incentive for reduction in repair costs is provided, since any reduction in labor hours or material costs used in repairing the equipment will increase the contractor's profits.

f. Minimal initial investment for support equipment is required by the government, since the contractor is to provide repair services during the warranty period.

g. RIW usage may reduce requirements for skilled military maintenance and support manpower.

2. Benefits to the Contractor.

a. Increased profit potential when MTBF is improved above pricing base.

b. Multi-year guaranteed repair business during the warranty period.

c. The contractor becomes more familiar with the operational reliability and maintainability of his equipment, which should help him in obtaining follow-on contracts.

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[3] The total cost tc the government for the development, acquisition, operation and logistic support of a system over a defined life span.

E. CONTRACTOR RISK

The major concern about the use of RIW has been the monetary risk to which a contractor may be exposed. The risk is caused by uncertainty in the field failure rate of the warranted equipment. The key element in the contractor's pricing of a RIW is the predicted number of returned items the contractor will have to process and repair during the warranty period. If the contractor's estimate of this rate of return is too low he can suffer a decrease in profits or even a monetary loss. Conversely, if his estimate is too high and he prices the RIW accordingly he stands to lose the contract to a lower bidder, or if he is awarded the contract will experience excess profits. New equipment, for which no field failure data is available, is the riskiest to warrant, while equipment which has been deployed and which has a known field failure rate provides the least risk. As mentioned previously, however, the anticipated RIW benefits for the government are greater for new equipment than for equipment already in the field. The balance between risk and benefits can be partially maintained by the price of the RIW and various contract clauses or exclusions that attempt to lower uncertainty.

II. INTERRELATIONSHIPS OR RIW WITH FIELD RELIABILITY, CONTRACTOR RISK, AND GOVERNMENT COST

A. RIW AND FIELD RELIABILITY

RIW seeks to improve combat effectivenss by improving field reliability. One of the problems associated with this approach is defining field reliability in terms that can be measured. Historically, reliability values have been stated in terms of Mean Time Between Failure (MTBF) which describes the expected number of failures due to inherent system design. The design specifications for reliability normally include specific environmental conditions such as temperature, vibration and humidity. Unfortunately, the projected reliability performance based on these specifications has been much higher, often by a factor of ten or more, than the reliability experienced by the equipment in the field (Figure 3). The reasons for this discrepancy are easy to identify but hard to correct. A large proportion of field failures are due to causes which are hard to define in specifications (Figure 4). Even if all field failure causes could be identified and included in the reliability specifications, a demonstration test to show that these specifications had been met would have to be a full field test utilizing operational personnel and conducted in an operational environment. The time and money necessary to conduct this type of testing is not available.

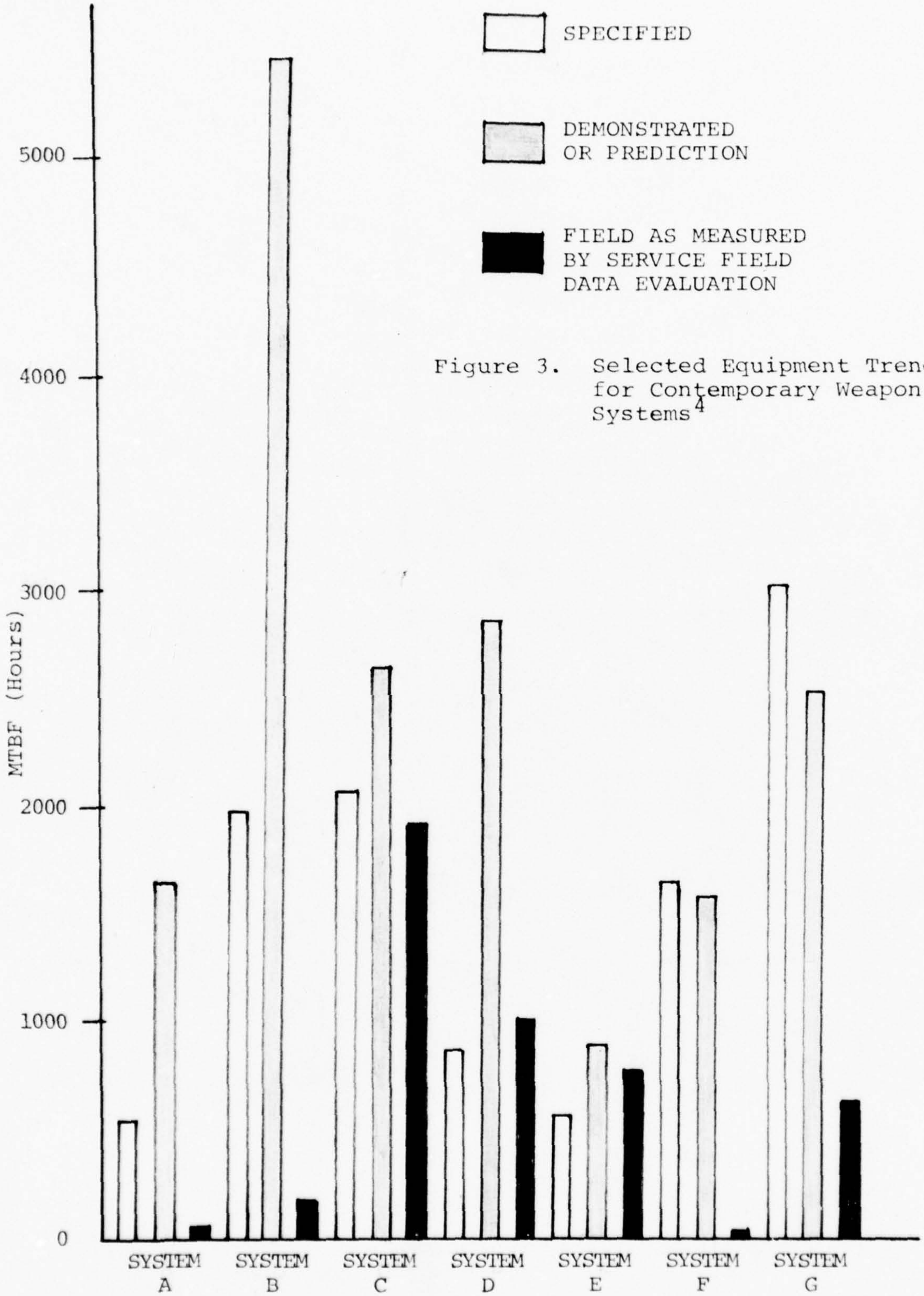

Figure 3. Selected Equipment Trend for Contemporary Weapon Systems[4]

[4] "Evaluation of Environmental Profiles for Reliability Demonstration," RADC-TR-75-242, Rome Air Development Center, Griffiss Air Force Base, New York, September 1975.

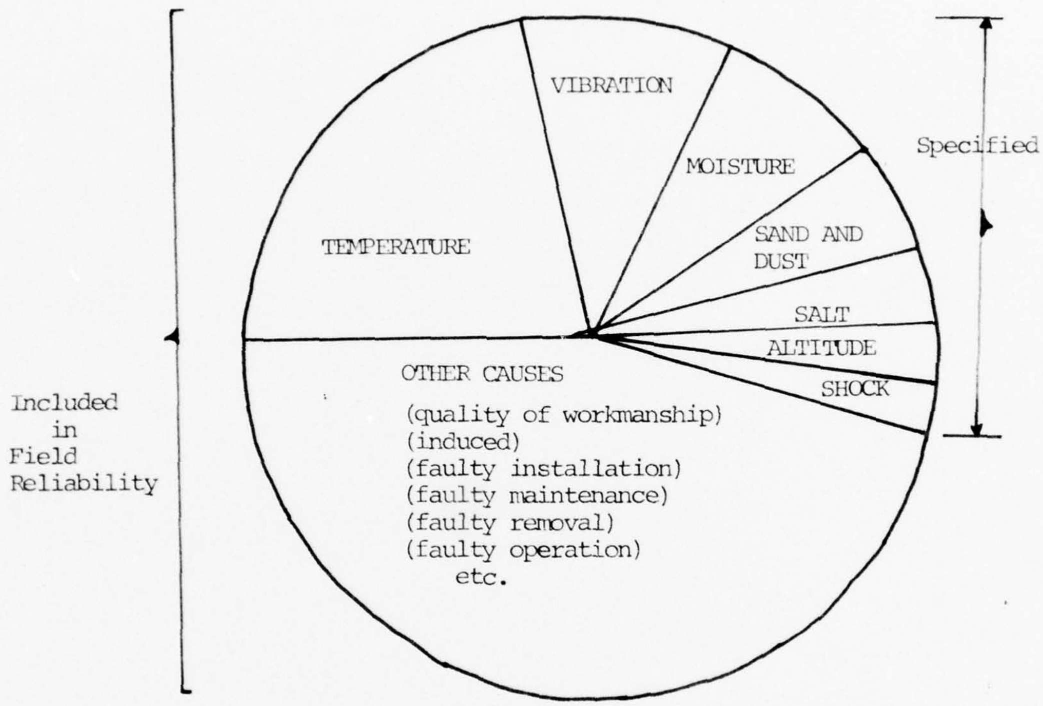

Figure 4. Avionics Equipment Failure Causes[5]

[5] A. Dantowitz, G. Hirschberger, and D. Pravidlo, "Analysis of Aeronautical Equipment Environmental Failures," Technical Report AFFDL-TR-71-22, Air Force Flight Dynamics Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, May 1971.

RIW attempts to solve this problem by obligating the contractor to repair all equipment that is returned to him during the warranty period for a fixed price. Although certain failure classifications may be excluded, the effect of RIW is that the contractor must consider the field reliability of his equipment. In order to make a profit, the contractor must analyze these failures and improve the reliability of the equipment through ECPs. Extensive environmental, operational and field data is provided to the contractor to aid his effort.

Since any corrective maintenance action in the field constitutes a field failure, fewer exclusions force the contractor to deal with a more realistic approximation of the actual field failure rate. Even with a large number of exclusions this rate is more reflective of the actual field failure rate than the old method of specifying inherent design MTBF since more failure categories are included.

B. IMPACT OF RIW ON COMBAT EFFECTIVENESS

Combat effectiveness can be defined as the product of three factors; performance of the system, the availability of the system, and the mission reliability of the system. RIW impacts on the latter two components (Figure 5). Availability, which is a probability measure of the system being up when it is needed, is defined as the ratio of the equipments up time (reliability) and its down time (maintainability). Since the main objective of RIW is to increase

Effectiveness = Performance x Availability x Reliability

RIW can impact these
two components

$$\text{Availability} = \frac{\text{MTBF}}{\text{MTBF} + \text{MTTR}}$$

MTBF - Common Measure of Reliability

MTTR (Mean time to repair) Common Measure of Maintainability

(1) Through incentive of RIW MTBF can be increased, the wider the warranty coverage (less exclusions) the closer MTBF approaches field MTBF

(2) RIW indirectly decreases MTTR

(a) Built in test equipment makes failure diagnosis easy.

(b) Black box replacement makes field replacement easy

(c) Fixed price incentive causes contractor to try to keep repairs simple and cheap

(d) Specified turn around times keep supply delays down

Reliability: Electronic components generally have constant failure rates. So

$$R = e^{-\lambda t} \qquad \lambda = \frac{1}{\text{MTBF}}$$

Mechanical systems, unfortunately, do not exhibit constant failure rates, however, their failure rates are often approximated by using a constant failure rate over a specified time interval.

(1) Through incentive of RIW MTBF can be increased, the wider the warranty coverage (less exclusions) the closer MTBF approaches field MTBF.

Figure 5. RIW Impact on Combat Effectiveness

reliability, availability is also increased. To a lesser extent RIW can lead to a decrease in down time, further improving availability. The mission reliability of the system is a measure of the probability that the system will remain up during the mission duration. Since this term is inversely proportional to the failure rate and RIW lowers the failure rate, this term is also increased. Clauses in new contracts frequently contain exclusions for damages to equipment caused by mishandling, improper installation, improper operation and unverified failures. The use of these and similar exclusion cause availability and reliability to be less reflective of actual operational values, therefore, the most effective warranty, from the government's viewpoint is one that has no exclusions.

C. IMPACT ON DESIGN

The maximum government benefits would come from applying RIW to procurement of new equipment because the contractor can then consider reliability in his design effort and make tradeoffs regarding production cost, reliability and repair costs where they will have their maximum effect. The equipment should, therefore have an initial failure rate that is lower than equipment procured under other methods. This failure rate will be further lowered during the warranty period. An RIW applied to an overhaul contract is less effective in this regard since the contractor is dealing with an existing design. Although he can make ECP's that improve reliability he can not alter the basic design of the equipment.

D. LIFE CYCLE COSTS

A general equation for describing Life Cycle Cost is:

$$LCC = \underset{\text{Cost}}{\text{Research \& Development}} + \underset{\text{Cost}}{\text{Production}} + \underset{\text{Cost}}{\text{Operating}} + \underset{\text{Cost}}{\text{Support}} + \underset{\text{Cost}}{\text{Retirement}}$$

RIW alters the emphasis the contractor places on the first three terms on the right hand side of this equation. Under the traditional method of specifying a design MTBF the contractors main concern is to keep development and production costs as low as possible. Under RIW, however, the contractor is forced to consider his repair costs once the equipment is put in the field. This effects development costs indirectly. Development costs are effected since the contractor is given the incentive to consider reliability during the design stage. He will devote more effort in this direction which will result in added development cost. Production cost usually will be increased also as better quality material is used and the contractor uses better quality assurance and testing techniques. If the design effort leads the contractor to develop less complex equipment, however, his production cost could go down. The cost of the production contract, however, will be higher since the cost of the RIW clause will be added to the cost of producing

the equipment. Operating and support costs will be decreased since the price of the RIW includes repair costs for the warranty period. Post warranty operating and support costs should also be decreased since the RIW acts to increase reliability.

The overall effect of a RIW contract should be to drive the total costs of the system toward the low point on the total cost curve (Figure 6). Applying RIW to a contract does not guarantee reaching this point, however. The answer lies in performing an accurate economic analysis to determine the cost savings that are expected prior to application and choosing the least expensive alternative. If the RIW alternative is chosen another evaluation can be performed to determine the actual cost savings at the end of the warranty period.

Although an RIW may not reduce system life cycle cost, it does have the benefit of providing more certainty concerning repair cost over the warranty period. This factor coupled with the increase in field reliability provided by RIW is a considerable benefit that is hard to measure in monetary terms but should also be considered in determining if a RIW should be used.

E. INDUSTRY CONCERNS

The Council of Defense and Space Industry Association (CODSIA) has been the primary spokesman for expressing industry concerns over use of RIW. The primary concern

Life Cycle Costs = Development Costs + Production Costs + Operating Support Costs + System Retirement Costs

(As a rule of thumb: [Operating and Support Costs] $\leq$ 5 [Development and Production Costs])

RIW CAN INCREASE:

Development Costs - indirectly by causing contractor to devote more effort to reliability

Production Costs - indirectly by causing contractor to use better material, having better Q.A., better testing

- directly by adding cost of RIW to production contract

RIW CAN DECREASE:

Operating + Support Costs - directly by increasing MTBF thus reducing maintenance, logistics, and repair costs

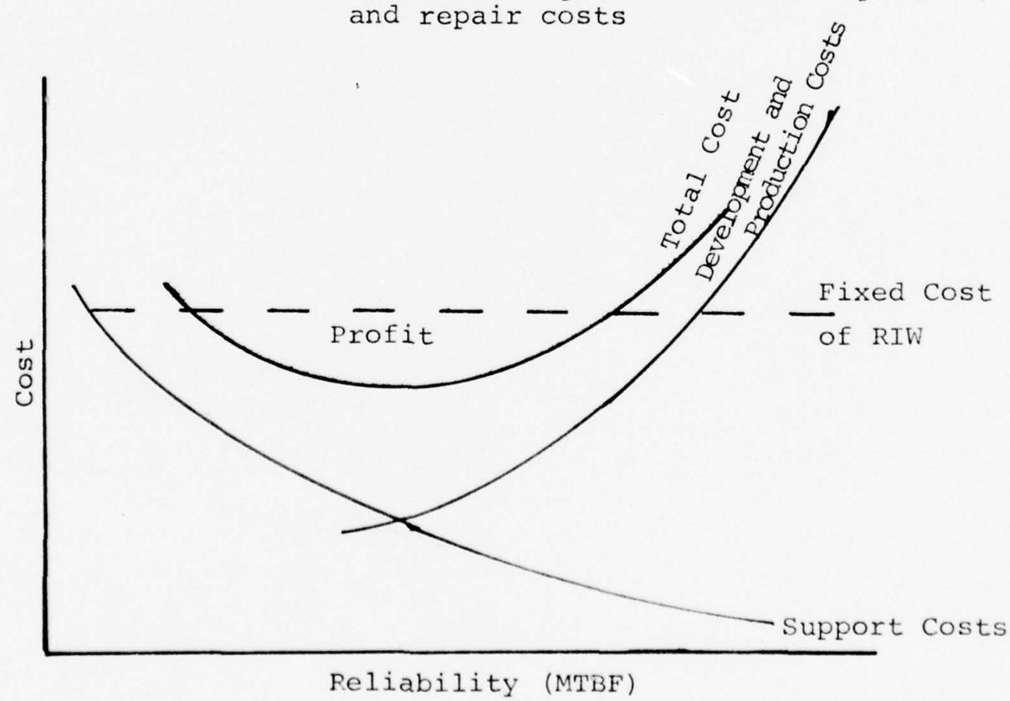

Figure 6. RIW Impact on Life Cycle Costs

expressed by this group revolves around the monetary risk the contractor is exposed to when an RIW is used. The risk is greatest when RIW is applied to the first production contract of new "state of the art" equipment since no actual field failure data is available and the uncertainty in predicting the expected field failure rate is high. Conversely this is the type of equipment where the government expects to gain the most from RIW application (Figure 7).

The uncertainty in predicting the field failure rate is increased by the "broadness of the warranty" since failures due to other than inherent design defects become increasingly difficult to predict. Industry, therefore, would prefer RIW warranties with a large number of exclusions. The government, on the other hand, prefers a broad warranty since it has a greater impact on field reliability and is easier to administer. The opposite positions of the government and industry are depicted in Figure 8.

If new equipment were to be covered by RIW, CODSIA has proposed the use of a cost plus incentive fee type contract to cover initial production. The incentive fee would be based on meeting a target MTBF. A fixed price RIW would then be applied to the equipment after field failure rate data becomes available. Industry also feels that RIW contracts provide harsh penalties if specified turnaround times are not met. These penalties usually obligate the contractor to assign extra spares to the government, at no additional

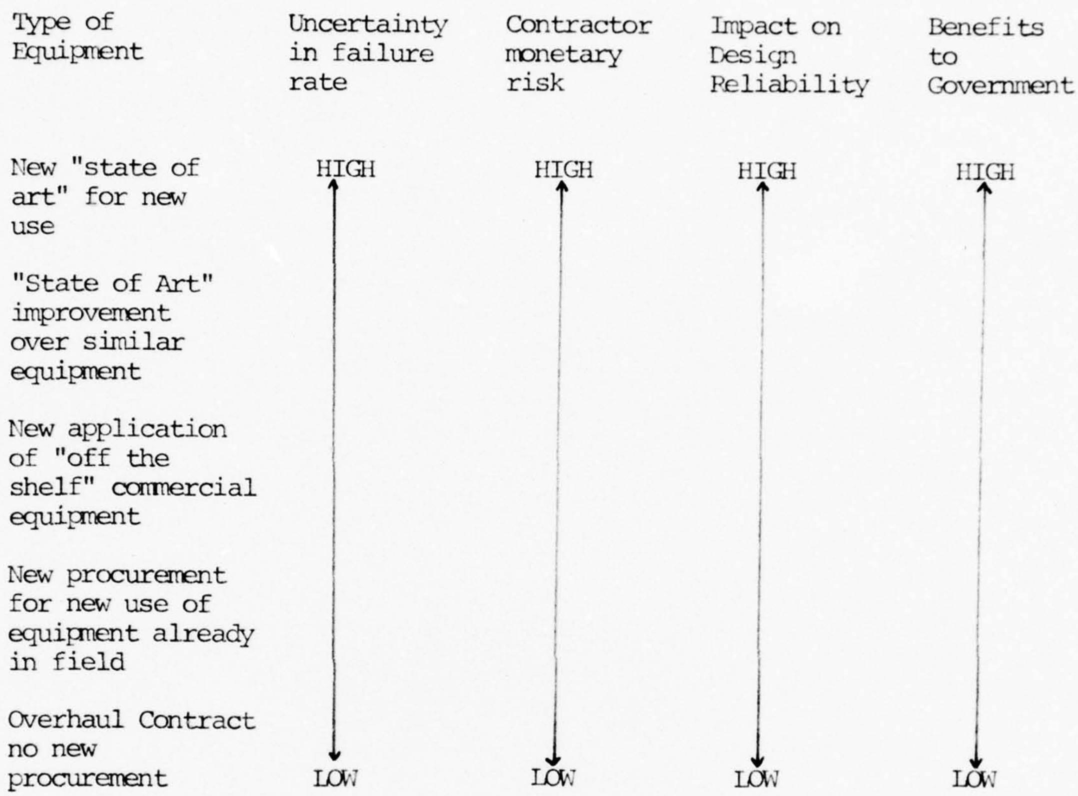

Figure 7. Contractor Risk and Government Benefits for Differing Types of Equipment Covered by RIW

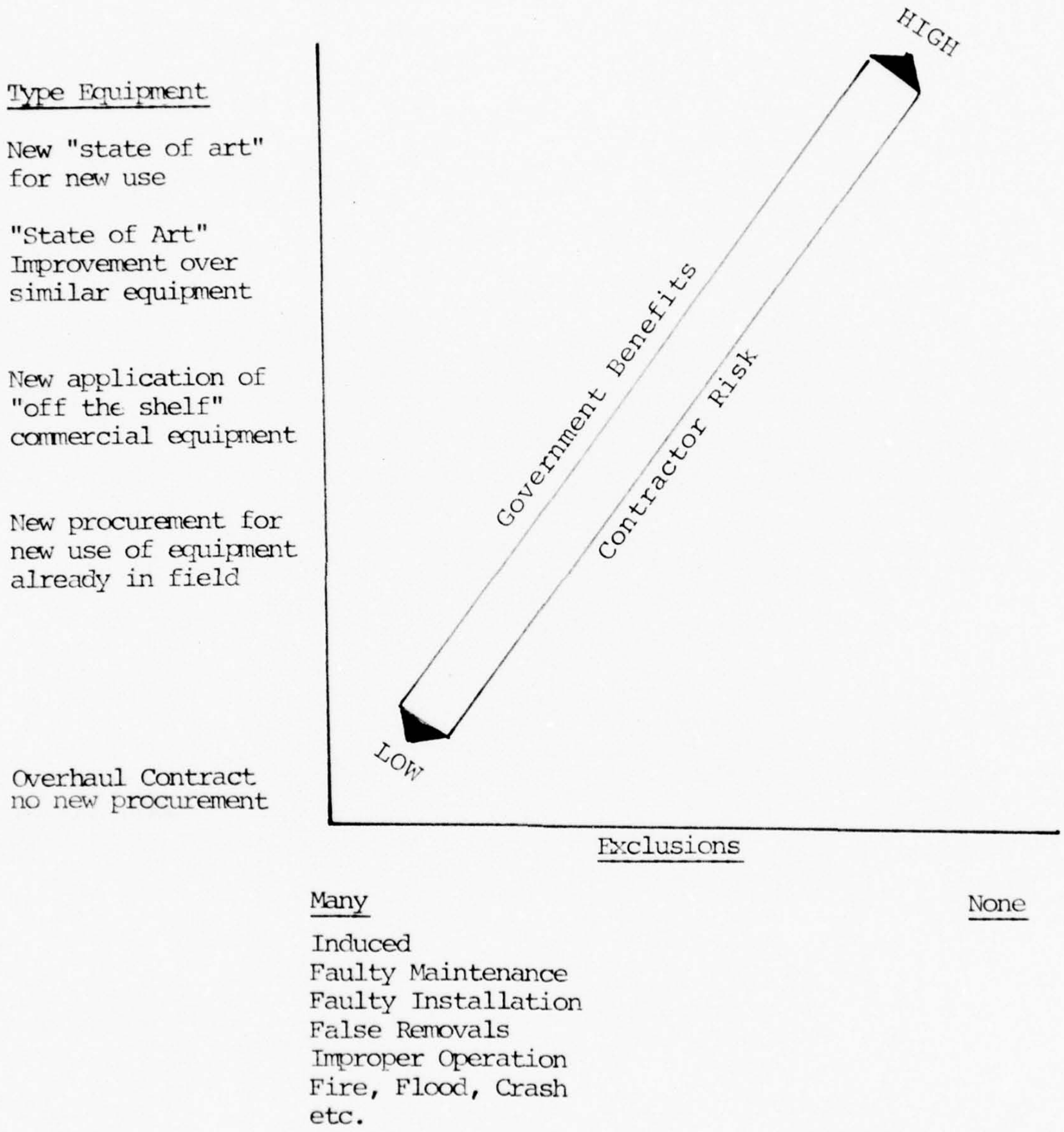

Figure 8. Contrast of Government Benefits - Contractor Risk with Differing Equipment Type and Contract Exclusions

cost, until the turnaround time improves or assess the contractor monetary penalty for each day late. The penalties are made even harsher by a RIW contract that includes a MTBF guarantee since if the MTBF values are not met, additional spares must be provided until the MTBF is improved.

The government desires these features in a RIW contract since a short turnaround time decreases its need for spares. The inclusion of a MTBF guarantee in a RIW contract also affords added protection to the government. Specifically, it may force the contractor to make an ECP to meet the stated MTBF, whereas, under a straight RIW the contractor may choose not to make the change since it would be less expensive for him to continue making repairs. This is especially true near the end of a warranty period where an ECP is less cost effective for the contractor. The differing viewpoints of industry and the government are depicted in Table 2.

Table 2. Government and Contractor Positions on RIW

Government	Contractor
1. Maximum benefits when applied to new equipment	1. Would prefer to apply to equipment already in field.
2. Apply to first production contract	2. Delay application until field data available (field test before warranty)
3. Minimum exclusions - best warranty the broadest warranty	3. Specific exclusions for: (a) fire (b) explosion (c) submersion (d) flood (e) aircraft (vehicle crash) (f) enemy action (g) seal broken on unit while outside contractor's control (h) external physical damage caused by accident or willful mistreatment (i) internal physical damage caused by accompanying external damage due to mistreatment or tampering by non-contractor personnel (k) induced failures (l) consequential/incidental damages (m) unverified failures ("retest OK") (n) improper installation/ operation/maintenance (o) designed, developed or produced by others than warranter.
4. Firm fixed price provides max incentive	4. Cost + incentive fee based on meeting target MTBF.
5. Use MTBF guarantee if cost effective and appropriate with RIW as determined by an economic analysis of the cost of the MTBF guarantee	5. Never use RIW with MTBF guarantee
6. Short TAT less expensive since need to buy less spares	6. Wants minimum penalties for exceeding turnaround time.

III. CONTRACT ANALYSIS

RIW contracts listed in Tables 3 and 4 were evaluated in terms of the following categories:

1. Nature of Equipment
    a. New state of art for a new purpose.
    b. State of art improvement over existing equipment.
    c. New military application of commercial "off the shelf equipment".
    d. Additional procurement of existing military equipment.
    e. Overhaul contract, applied to existing military equipment already in field.
2. Exclusion clauses.
3. Use of MTBF guaranties and penalties
4. Turnaround time and penalties
5. Price
6. MTBF improvement realized.

Additionally, the difference in price between sole source and competitive contacts was compared, the contracts were evaluated in terms of contractor risk and potential government benefit, the changes in RIW application since the 1974 memorandum by DDR&E and OSD(I&L) were analyzed and the use of RIW by the three armed services was compared. Finally, the cost effectiveness of the only completed long term RIW contract, the first USN(ASO/LSI overhaul contract for the AJB-3 gyro), was evaluated.

Table 3. Long Term RIW Contracts (>4 years)

Item	Manufacturer	Service	Year	Warranty Period
CN494A/AJB-3	LSI	USN(ASO)	1967-first contract 1973-second contract	5 yrs/1500 hrs per unit 6 yrs/1.2 million total operating hours
A24G-27 Gyro	LSI	USAF	1969	5 yrs/3,000 hours per unit
APN-194 Radar Altimeter	Honeywell	USN(ASO)	1975-2nd contract	5 years
F-14 Hydraulic Pump	ABEX	USN(ASO)	1973	6 yrs/387,000 operating hours
AN/ARN118 (1) Tacan	Collins	USAF	1975	5 years
ARN123VOR/ILS (1)	Bendix	USA	1975	4 years
F-16 ACF systems (2)	General Dynamics	USAF	1976-under negotiation	4 years/300,000 operating hours

(1) Contract includes MTBF guarantee

(2) Contract has three options: RIW
RIW with MTBF guarantee
LSC

Table 4. Short Term Contracts with RIW Provisions
(<26 months)

Item	Manufacturer	Service	Year Awarded	Warranty Period
APN 154 Radar Beacon	UTE	USN	1972	26 months/1000 operating hours
APN 99V Ω Receiver	Northrop	USN (NAVAIR)	1973	2 years
AAU-32A Barometric Altimeter	Kolsman	USN (NAVAIR)	prior to 1974	2 years
APN-194 Radalt	Honeywell	USN (NAVAIR)	1972	2 years/1500 operating hours
INS Carousel IV[1]	Delco	USAF	1972	1 year

[1] Contains MTBF guarantee

The contracts were separated into two groups, long term (over 4 years) and short term (under 26 months) for purposes of the evaluation since the shorter term contracts do not represent full potential of RIW. These contracts are included in the study, however, since they do represent application of RIW.

A. CONTRACTS

<u>CN494A/AJB-3 Gyro, Contract between Naval Aviation Supply Office and Lear Siegler (LSI)</u>

This was the first military use of RIW and represents the only completed RIW contract for which a large data base exists. The contract, signed in 1967, covered the repair of 800 gyros for a five year period. The gyros had been in field use for a number of years and were being repaired commercially by LSI and General Electric so actual field failure and cost to repair data could be calculated. Additionally, the 800 gyros placed under warranty represented only about one third of the total gyro population so a direct comparison could be made between warranted and unwarranted units. Possible savings to the Navy were based upon the achievement of 1.2 million operating hours or 1500 hrs/unit during the five year period. The initial MTBF was calculated to be 400 hours and the target MTBF was set at 520 hours. The total cost of the RIW was estimated to be $3.444 million based upon the induction of 800 "new" gyros at a cost of $4305 per unit. A savings of $686,000,

or 57¢ per operating hour was projected. This contract was completed in 1973 and a follow-on contract with LSI negotiated for the original 800 gyros. The follow-on contract has four major differences. The contract price is lower ($2.5 million, vice $3.44 million), operating time of 1.2 million hours is based on the total units covered and not limited to 1500 hours per unit, the calendar time period has been extended to six years, and the Navy has the option of including additional gyros under the contract if it is seen that utilization will not meet the anticipated 1.2 million operating hours over the six year period [Ref. 26]. The cost of the second contract is lower due to the reduction in repair time which resulted from reliability improvements made to the gyros during the first contract. The cost of the first contract was based on an average repair time of 75 hours per gyro. The cost of the second contract was negotiated with a repair time of only 45 hours.

A24G-27 Gyro, Contract between USAF and LSI

In 1969 the Air Force signed a RIW contract with LSI for maintenance of 128 gyros used in the F111 aircraft. The contract is for a 5 year or 3,000 operating hours per unit period and was the result of a competitive procurement between LSI and General Electric. This contract represented an additional procurement of gyros that were already in field use. The cost effectiveness of the contract would therefore be directly evaluated against non-warranted units.

The unit production cost of the gyro was $6040 and the warranty cost is $2200 which represents a repair cost of 7.3% of unit price per year [Ref. 15].

F-14 Engine Driven Hydraulic Pump, Contract between USN (ASO) and Abex Corporation

This six year/387,000 operating hour contract was negotiated in 1973 and covered 258 units at a cost of $1016 per unit per year. It was significant for several reasons. Although ABEX had considerable field experiences with hydraulic pumps this pump was larger and represented a new state of the art design. The contract is the broadest warranty under RIW to date in that ABEX agreed to repair all pumps returned to them with no exclusions. It incorporated a pool arrangement in which the contractor kept a supply of ready to issue pumps on hand in order to meet a 24 hour turnaround time from notification of a failure until a replacement pump was sent from the factory. The contract price was based on an expected MTBF of 500 hours during the first year growing to 750 hours in the last year [Ref. 25].

APN 194 Radar Altimeter, Contract between USN and Honeywell Corporation

The initial procurement contract awarded to Honeywell for the APN-194 contained an RIW clause. The period of coverage under this contract was for two years or 1500 hours per unit and the cost of the warranty has been estimated to be about 7% of the purchase price. The APN-194 was a new radar altimeter intended to replace the APN-141 which was

experiencing a 50 hour MTBF. Although this contract had an RIW clause it was basically a maintenance service contract since it covered a short time period (2 years) and the cost of ECP's was jointly shared by Honeywell and the Navy.

ASO has recently negotiated with Honeywell to provide a long term (5 year) RIW contract for the APN-194. The current MTBF of the unit is estimated to be about 465 hours. Under the RIW this MTBF is projected to grow to over 1040 hours at the end of the five year period [Ref. 26].

AN/ARN-118 Tacan, Contract between USAF and Rockwell Collins Radio

This contract was signed in July 1975 and was the outcome of a design to cost competition between Collins and General Dynamics/Electronics. The winning Collins bid was $9,400 per tacan, with an additional $500 per year per set for a period of five years under RIW. The initial contract calls for the coverage of 1000 units, with additional multi year options of 7,300 units. The tacan is a state of art improvement over existing tacan sets. The RIW agreement contains a MTBF guarantee of 500 hours for the first twelve months, 625 hours for months 13-24 and 800 hours for months 25-48. If the field MTBF falls below these levels Collins is required to supply additional spares to the Air Force with no charge as well as making design changes to increase reliability [Ref. 8].

AN/ARN 123 VOR - Contract between USA and Bendix

Bendix won this competitive procurement for 1,139 VOR sets over four other bidders and signed the contract in 1975. The contract covers a four year period and like the Air Force tacan contract includes a MTBF guarantee. The VOR set is required to demonstrate a field MTBF of 500 hours for the first year, rising to 600 hours during the second year and 700 hours for the third year. If these values are not met Bendix must determine the cause, take corrective action, and conduct additional environmental testing at no charge [Ref. 16]. The ARN 123 is a standard commercial unit that has been in use in the civilian environment for several years, however, this is the first military application. Even with the MTBF guarantee the unit per year cost of the RIW is only 2.7% of the purchase price, the lowest percentage price for any military RIW agreement. This low figure is representative of the high confidence Bendix has in the unit which has exhibited a MTBF of greater than 1000 hours in the civilian environment [Ref. 22].

F-16 Components, Contract between USAF and General Dynamics

The most ambitious RIW proposal to data is currently under negotiation. The contract could call for RIW coverage for up to twelve critical subsystems which have been defined as contol first line units (FLUs). The contract could apply any of three different concepts. RIW with a provision for turnaround time, RIW with a MTBF guarantee, and a comparison

between Target Logistic Cost and measured Logistic Support Cost. Under the latter concept the actual logistic support cost will be computed based on data accumulated during a verification test of 3500 flight hours. The test will commence six months after the first F-16 squadron becomes operational. If the measured value does not exceed the target value, the contractor is eligible for an award fee. If the total measured value exceeds the total target value by greater than 25% the contractor must initiate a correction of deficiencies (COD).

Under the RIW option, the warranty period is 48 months or 300,000 flight hours, whichever comes first and the Air Force reserves the option to extend the contract in increments of 24 months or equivalent flying hours. The contract specifies a maximum of twenty two days between contractor receipt of a failed FLU and placement of the repaired item in a secure storage area. The contractor must provide extra spares if the turnaround time is exceeded.

The RIW with a MTBF guarantee option provides for four penalties if the computed MTBF for a given measurement period is less than the guarantee value for that period. The contractor is obligated to:

1. Perform engineering analysis to identify the cause of noncompliance.

2. Initiate corrective ECPs.

3. Modify existing units in accordance with approved changes.

4. Provide additional spares on a loan basis until guaranteed MTBF's are met.

Both RIW options are under Separate Firmed Fixed Price proposals while the LSC option is on a Cost Plus Incentive fee basis [Ref. 24].

B. SHORT TERM CONTRACTS

Several other contracts have included RIW provisions (Table 4), however, these are basically maintenance service type contracts for short time periods (26 months or less). The short time period of these contracts does not provide any incentive for the contractor to initiate any but the least expensive ECP's since the number of repairs he would reduce by initiating an ECP would not offset the cost of the ECP. These contracts, therefore, do not have an incentive for the contractor to improve reliability during the warranty period and are not RIW's in the strict sense. They do offer insurance to the government, however, in that the contractor would lose money on the cost of repairs if the number of actual repairs exceeded the number that was used in pricing the warranty agreement. The contractor therefore has a strong incentive to provide equipment that has an initially high reliability. Another advantage to the government is knowing that repair costs for the warranty period are fixed.

C. TYPES OF EQUIPMENT WARRANTED

Of the eight long term (greater than 4 years) RIW contracts now in force or under negotiation three are overhaul contracts, one is an additional procurement of existing military equipment, one is a new military application of commercial equipment, two are applied to equipment that is a state of the art improvement over existing equipment, and one (F-16) covers units ranging from new procurements of existing equipment to state of the art equipment improvements (Table 5). Of the five short term contracts, three were for additional procurements of existing equipment, one for an equipment that was a state of the art improvement over existing equipment, and one a new military application of commercial equipment.

When the contracts are identified by the military service (Table 6), it is clear that the Navy has applied RIW primarily to overhaul contracts for long term RIW, while the Air Force has used the concept for production contracts. The Navy procurement contracts that have used RIW are primarily for a short term period (<26 months), except for the ABEX contract, and are basically maintenance service contracts. The lone Army application was a procurement of an "off the shelf" commercial item.

D. EXCLUSION CLAUSES

The basic exclusion clause in most RIW contracts to date has included exclusions for:

Table 5. Types of Equipment Warranted

	Long Term (>4 years) RIW Contracts	Short Term (<26 months) Contracts Containing RIW Provisions
New "state of art" for new use	-	-
State of Art Improvement over Similar Equipment	F-14 Hydraulic Pump AN/ARN 118 Tacan F-16 Components	APN-194 Radar Altimeter (1st contract)
New Application of "off the shelf" commercial equipment	AN/ARN 123 VOR F-16 Components	INS Carousel IV
New Procurement for New Use of Equipment Already In Field	A24G-27 Gyro F-16 Components	APN 154 Radar Beacon AAU-3A Barometric Altimeter ARN99V Omega Receiver
Overhaul Contract No New Procurement	CN494A/AJB-3 Gyro (two contracts) APN-194 Radar Altimeter (2nd Contract)	-

Table 6. Service Use of Warranties

	Long Term (>4 years) RIW Contracts			Short Term (<26 monts) Contracts Containing RIW Provisions		
	USN	USAF	USA	USN	USAF	USA
New "state of art" for new use	–	–	–	–	–	–
"State of Art" Improvement over similar equipment	F-14 Hydraulic Pump	AN/ARN 118 Tacan F-16 Components	–	APN-194 Radar Altimeter (1st contract)	–	–
New application of "off the shelf" commercial equipment	–	F-16 compon-ents	AN/ARN 123 VOR	–	INS Carousel IV	–
New Procurement for new use of equipment already in field	–	A24G-27 Gyro F-16 Components		APN 154 Radar Beacon AAU-3A Barometric Altimeter ARN99V Omega Receiver	–	–
Overhaul contract No New Procure-ment	CN494A/ AJB-3 Gyro (two contracts) APN-194 Radar Altimeter (2nd contract)					

1. fire

2. explosion

3. submersion

4. crash

5. enemy action

6. damage caused by mishandling, improper installation, improper operation, and accident

7. broken seal on unit.

The lone exception to these types of exclusions is the contract covering the ABEX hydraulic pump for the F-14 aircraft which contains the clause:

> "In the event a warranted unit is lost or destroyed, an additional government owned unit will be introduced into the warranty population and will assume the unexpired warranty of the unit lost or destroyed at no increase in contract price. If such replacement is not possible (e.g., because all existing units are covered by similar warranty) the U.S. Navy may elect to procure a replacement unit or the parties hereunder may negotiate an appropriate extension of the calendar limitations." [Ref. 14]

The number of items that would normally fall under these exclusions, however, are limited and will generally not have a large impact on the number of returns the contractor must process and repair.

A major item that can effect contractor costs under RIW is the return of units that "test good." A large number of these unverified failures significantly raise costs to the contractor since he must test and process all units returned to him. If the contract contains an MTBF guarantee,

the contractor is also penalized if unverified failures are included in calculating the field MTBF of the equipment. RIW contracts, with the exception of those including a MTBF guarantee, have not included special provisions for unverified failures. The number of unverified failures for the equipment that have occurred in the past (if field data is available) or an estimate of the number of unverified failures is usually used in calculating the price of the RIW. The government indirectly pays this price when it purchases the RIW. This provides the contractor the opportunity to increase his profit if he can lower the rate of unverified failure returns. Contracts containing a MTBF guarantee have excluded unverified failures from the MTBF calculation and have, in two of four cases, contained a provision to pay a fixed fee per unit if unverified failures exceeded a specified rate. The use of exclusions is summarized in Table 7.

E. MTBF GUARANTEES AND PENALTIES

Two RIW contracts containing MTBF guarantees have recently been signed. One by the Army for procurement of An/ARN-123 VOR navigational equipment and one by the Air Force for procurement of a new generation Tacan set. Additionally the proposed contract for the F-16 fighter has an MTBF guarantee option to cover up to 12 control FLU's. An earlier procurement of inertial navigational equipment by the Air Force also contained a MTBF guarantee. The

Table 7. Use of Exclusions

	Standard Exclusion and provision for unverified failures (1)	Standard Exclusion	No. Exclusions
Long term RIW >4 yrs	AN/ARN-123 VOR (2)	AJB-3 Gyro (both contracts)	Abex hydraulic pump.
	AN/ARN-118 Tacan (2)	APN-194 Radalt (second contract)	
		A24G-27 Gyro	
		F-16 components (3)	
Short term RIW provision (<26 mos)		APN-194 (1st contract)	
		APN-154 Radar Beacon	
		ARN 99V Ω Receiver	
		AAU-32A Baralt	
		INS Carousel (IV) (2)	

(1) government will reimburse contractor $100 for every unverified failure over 30%.

(2) MTBF guarantee - unverified failures not counted.

(3) MTBF guarantee option unverified failures not counted.

guaranteed MTBF values and associated penalties to be evoked if the specified values are not met are summarized in Table 8. The penalty clauses used are virtually identical. They provide for identification of the cause of failures, corrective no cost ECP's, and providing additional spares until stated MTBF's are met.

Under a straight RIW the contractor has the option of improving the reliability of the equipment or of repairing more units if the reliability is not improved. The latter choice may be more cost effective to him especially during the later stages of the warranty period. The MTBF guarantee removes this option by evoking a heavy penalty by use of the provision for providing additional spares at no cost to the government. From a contractor's standpoint, therefore, there is a high degree of monetary risk involved in a contract containing a MTBF guarantee than in a straight RIW for the same equipment.

F. TURNAROUND TIME PROVISIONS

Turnaround time is important to the government since it has a direct impact on the availability of the equipment in the fleet. If MTBF is constant and turnaround time increases,the field availability will decrease due to spares not being in stock. Availability can be increased by an increase in the amount of spares available, however, this is achieved at the expense of buying additional spares.

Table 8. MTBF Guarantees and Penalties

Item	Guaranteed MTBF (hours)	Penalty
AN/ARN-123 VOR	1st year - 500 2nd year - 600 3rd year - 700	Engineering analysis to determine cause, corrective ECP's, additional environmental testing
AN/ARN-118 Tacan	1-12 months - 500 13-24 months - 625 25-48 months - 800	Supply additional spares at no cost determine cause corrective ECP's
F-16 Components[1]	RIW/MTBF Guarantee option	
Inertial Navigational Unit	1-12 months - 185 13-24 months - 284 25-36 months - 300	Engineering analysis to determine causes, corrective ECP's, provide additional spares according to formula
Flight Control Computer	1-12 months - 162 13-24 months - 242 25-48 months - 260	" "
Radar E/O Display	1-12 months - 155 13-24 months - 228 25-48 months - 244	" "
HUD Display	1-12 months - 170 13-24 months - 212 25-48 months - 224	" "
Digital Scan Converter	1-12 months - 210 13-24 months - 330 25-48 months - 350	" "
Fire Control Computer	1-12 months - 415 13-24 months - 600 25-48 months - 640	" "
HUD Electronics	1-12 months - 325 13-24 months - 470 25-48 months - 500	" "
E/O Display Electronics	1-12 months - 155 13-24 months - 228 25-48 months - 244	"
INS Carousel IV	After 6 months - 1100	Improve system until MTBF value met, provide additional spares at 1/2 cost

(1) The MTBF guarantee is met if field MTBF meets or exceeds specified MTBF for two consecutive 6 month periods but no earlier than the 2-1/2 year point.

Specified contractor turnaround times and associated penalties are listed in Table 9. Turnaround times range from 24 hours for the F-14 hydraulic pump to a high of 60 days for the ARN 99V Ω Receiver. The extremely short turnaround time for the F-14 hydraulic pump is made possible by designating 25 of the 258 pumps procured as rotatable pool items that are kept "on the shelf" at the contractor's plant. Penalties associated with not meeting specified turnaround time fall into three categories; warranty extension, monetary penalty, or provision of additional spares. The warranty extension is probably the least effective penalty and causes additional detailed bookkeeping, while the provision for additional spares is the most effective since this helps to offset the lowered field availability caused by the increased turnaround time.

G. COST OF RIW

The cost of a RIW is frequently stated as a percentage derived from dividing the yearly warranty cost per unit by the original unit procurement cost. This method does not take into account differences in the terms and conditions of the individual warranties, which can effect the cost of the RIW. It does, however, offer a simple method of comparing the cost of RIW contracts. It also presents a guideline evaluating the cost of similar warranty provisions and establishing a price range. The cost of each RIW contract

Table 9. Turnaround Time

	Item	TAT	Penalty
Long term RIW contracts (>4 yrs)	AJB-3 gyro (2 contracts)	45-60 days	-
	F-14 Hudraulic pump	24 hr.	warranty extended 2 days for each day over 72 hours
	AN/APN 123 VOR	20 days	$10 per day for each day over 20
	AN/ARN 118 Tacan	20 days	$25 per day for each day over 20
	A-24G-27 gyro	45 days	--
	APN-194 Rad AH (2nd contract)	-	--
	F-16 components	22 days	contractor provides additional spares at no cost if not met
Short term RIW provisions (<26 months)	APN 194 Radalt	45 days	.5% of purchase price per day over 45
	INS CAROUSEL IV	--	--
	ARN 99V Ω Receiver	60 days	--
	AAU-32A Baralt	45 days	.5% of purchase price per day over 45
	ARN-154 Radar Beacon	30 days	extension of warranty period if not met

should be determined by an extensive economic analysis which evaluates the potential savings to the government and also takes into account the potential for reliability improvement.

Table 10 documents available RIW cost figures. From the data presented it appears that the cost of RIW has been decreasing with time, possibly because of more familiarity with the concept. It also appears as if the Navy has generally paid a higher percentage price for RIW than have the other services but this may be due to the reasons stated above.

In general competitive contracts appear to have been less costly. Of the nine contracts for which data was obtained five have been or are competitive. The average percentage cost for these contracts is about 6%. The cost of the four sole source contracts is about 17%. The Navy has negotiated all four of the sole source contracts and one competitive contract. While all Air Force and Army contracts have been competitive.

H. MTBF IMPROVEMENT

All RIW contracts for which data is available have resulted in reliability growth or improvement over replaced systems, expressed as an increase of MTBF. The increases have ranged from 30% to almost 200%, Table 11. Under the long term RIW contracts the contractors have used no cost ECP's to effect the increase in reliability for the AJB-3 gyro and the A24G-27 gyro. Although ABEX has originated 7 no cost ECP's to the F-14 hydraulic pump, insufficient data

Table 10. Cost of RIW [Ref. 14, 15, 16, 18]

Long Term (>4 years) RIW Contracts

Year	Equipment	Service	Unit Cost	Yearly RIW Cost per Unit	RIW Cost % (Yearly RIW cost per unit UNIT COST)
1967	CN 494A/AJB-3 Gyro (1st contract)	USN	3125	1016	33%
1969	A24G-27 Gyro	USAF	6040	440	7.3%
1973	F-14 Hydraulic Pump	USN	2900	478	16%
1973	CN494A/AJB-3	USN	3125	520	16.7%
1975	AN/ARN 123 VOR(1)	USA	1377	37	2.7%
1975	AN/ARN 118 Tacan(1)	USAF	9400	500	5.3%
1976	APN 194 Radar Altimeter (2nd contract)	USN	4900	--	estimate 2-3%
1976	F-16 Components(2)	USAF	7600-116,500 Avg. 62,000	--	4-10% (RIW), MTBF guarantee up to 93% higher
	Short Term (<26 months) Contracts Having RIW Provisions				
1972	APN-194 Radar Altimeter (1st Contract)	USN	4900	--	7%
1972	INS CAROUSEL IV(1)	USAF	100,000	8300	8.3%

(1) Contract contained MTBF guarantee

(2) Contract contains MTBF guarantee option

Table 11. MTBF Improvement

Item	
AJB-3 gyro (1st contract)	MTBF improved from 400 hrs to 520 hrs no date
AJB-3 gyro (2nd contract)	
APN-194 Radalt (1st contract)	Replaced APN 141 which had MTBF of 50 hrs. MTBF achieved 450 hour
F-14 Hydraulic Pump	7 no cost ECP's originated, not sufficient data for evaluation of reliability improvement
A24G-27 gyro	MTBF over 1200 hours for warranted gyro vice 749 hours for unwarranted unit
INS Carousel IV	MTBF commercial unit was 1100 hrs MTBF of USAF unit was 2208 hrs
AN/ARN 123VOR	No data yet, commercial unit has MTBF 1000 hrs. MTBF guarantee value - 700 hrs
AN/ARN 118 Tacan	Replaces AN/ARN-21/52/65/72 with MTBF's hour MTBF guarantee value - 800 hrs
APN 154 Radar Beacon	MTBF improved from 534 hrs to 2025 hrs
APN 194 Rad Alt (2nd contract)	Honeywell proposes to increase MTBF from 480 - 1110 hrs

is available to determine reliability improvement. The dramatic increases in the MTBF's of the INS Carousel IV and the APN 154 Radar Beacon, both short term contracts, were the result of changes incorporated in the production of the units rather than any changes made in the units after they were deployed.

I. RELATIONSHIP BETWEEN CONTRACTOR RISK AND RIW PRICE

If new equipment, with no field failure data, provides the greatest monetary risk for the contractor, this risk should be reflected in the RIW price and in the contract exclusions. Data for the eight long term RIW contracts does not substantiate this assumption. The two most expensive (calculated on a percentage basis) RIW contracts have been for overhaul contracts where extensive field failure and repair cost data was available. The broadest warranty to date, for the F-14 hydraulic pump had a high percentage cost but also had the shortest turnaround period. The use of a MTBF guarantee in the AN/ARN 118 Tacan and AN/ARN 123 VOR contracts did not appear to raise the cost of these warranties to a high level. The F-16 proposal shows that using an MTBF guarantee would raise the price of the warranty by 12% to 93% depending on the component warranted which indicates that a MTBF guarantee is more costly than a straight RIW. Warranty contracts for the "riskier" equipment also contain more penalty provisions with regard to turnaround time (Table 12).

Table 12. Contractor Risk; Long Term RIW Contracts

Contractor Risk	Price	Equipment	Exclusions	Turnaround Time
High	16%	F-14 hydraulic pump (new equipment)	no exclusions	24 hr TAT with penalty
	4.8%	AN/ARN 118 Tacan (new equipment)	Std. exclusions, provision for un-verified failures	MTBF guarantee with penalty 20 TAT with penalty
	4-10% RIW 12-93% higher with MTBF guarantee	F-16 components (new & existing equipment)	Std. exclusions	22 day TAT with penalty MTBF guarantee option with penalty
	2.7%	AN/ARN 123VOR (off the shelf)	Std. exclusion provision for un-verified failures	20 day TAT with penalty GMTBF with penalties
	7.3%	A24G-27 gyro (new procurement of existing equipment)	Std. exclusions	45 day TAT
	33%	CN494A/AJB-3 gyro (1st contract) overhaul contract	Std. exclusions	45-60 day TAT
	16.7%	CN494A/AJB-3 gyro (2nd contract) overhaul contract	Std. exclusions	45-60 day TAT
Low	2-3%	APN-194 Radalt (2nd contract)	Std. Exclusions	

Although pricing data concerning the short term RIW contracts (Table 13) is lacking, there seem to be no particular differences in exclusions or penalties between the "high" and "low" risk equipment.

J. COMPETITION

RIW contracts that have been competitive have been negotiated for a lower percentage cost than those that have been the result of a sole source negotiation. Of the nine contracts for which data was obtained four have been sole source and five have been competitive. The average percentage price of a sole source contract has been over 17% while the average percentage price of a competitive contract has been 5.8%, Table 14. The Navy has been the only service to apply sole source RIW contracts, it has also payed a higher percentage cost for warranties.

K. TRENDS IN RIW CONTRACTING

The DDR&E and OSD(I&L) memo of August 1974 establishing guidelines for RIW seems to have stimulated the use of RIW (Table 15). All RIW contracts since 1974 have been for long (4 years or greater) time periods. The Air Force, in particular, has attempted to apply the technique to new procurements. The contracts for the ARN-118 Tacan and the proposed contract for F-16 components are applications which offer the maximum benefits to the government. The F-16 contract is the most significant potential application of RIW to date. The avionic subsystems covered by a RIW option

Table 13. Contractor Risk; Short Term RIW Contracts

Risk	Price	Equipment	Turnaround Time, Penalties
High	7%	APN-194 Radalt (1st contract)	45 day TAT with penalty
	8.3%	INS Carousel IV	MTBF guarantee with penalty
	?	APN 154 Radar Beacon	30 day TAT with penalty
	?	AAU-3A Baralt	45 TAT with penalty
Low	?	ARN 99V Ω Receiver	60 day TAT

Table 14: Competitive - Sole Source Contracts by Service

Long Term (>4 years) RIW Contracts

Item	% Price	Type	Service
AJB-3 Gyro (1st contract)	33%	Sole Source	USN
AJB-3 Gyro (2nd contract)	16.7%	Sole Source	USN
F-14 Hydraulic Pump	16%	Sole Source	USN
APN-194 Radar Altimeter (2nd contract)	3% (est.)	Sole Source	USN
Average Sole Source	17.2%		
A24G-27 Gyro	7.3%	Competitive	USAF
F-16 Components	4-10%(RIW)	Competitive	USAF
AN/ARN 118 Tacan	4.8%	Competitive	USAF
AN/ARN 123 VOR	2.7%	Competitive	USA
Average Competitive	5.8%		

Table 15. RIW Contracts by Year

Year	Item	Warranty Period	Type Contract	Service
1967	AJB-3 Gyro	5 yr	overhaul	USN
1969	A24G-27 Gyro	5 yr	New Procurement existing equipment	USAF
1972	APN 154	26 mos.	new procurement existing equipment	USN
	APN 194 Radalt	2 yr	new procurement state of art improvement	USN
	INS Carousel IV(1)	1 yr	new procurement commercial equipment	USAF
1973	ARN 99V Ω Receiver	2 yr	new procurement existing equipment	USN
	F-14 hydraulic pump	6 yr	new procurement state of art improvement	USN
	AJB-3 gyro	6 yr	overhaul	USN
1974 (prior to)	AAU-32A Baralt	2 yr	new procurement existing equipment	USN
--------------DDR&E & OSD(I&L) Memorandum on RIW--------------------------				
1975	AN/ARN 118 Tacan(1)	5 yr	new procurement state of art improvement	USAF
	ARN 123 VOR/ ILS(1)	4 yr	new procurement commercial equipment	USA
1976	APN-194 Radalt	5 yr	overhaul	USN
	F-16 components(2) (proposed)	4 yr	new procurement mix of systems	USAF

(1) Includes MTBF guarantee

(2) Includes RIW option and RIW/MTBF guarantee option

represent the major cost-maintenance items in the program. This is also the first attempt to warrant complete sub-systems as previous warranties have covered individual "black boxes" only. The Army's first attempt at applying the RIW concept, the AN/ARN 123 VOR/ILS is a middle of the road approach. The Bendix VOR is a standard commercial item that has been widely used in civilian aviation and has demonstrated a MTBF in excess of 1000 hours in that environment [Ref. 22]. Meeting the guaranteed MTBF value of 700 hours after three years does not appear to present much risk to the contractor as represented by the low (2.7%) annual maintenance cost. The contract does provide insurance to the Army, however. Whether this is cost effective remains to be determined. Of the three services, the Navy seems to have taken the least risky approach to RIW contracting. Although the RIW for the F-14 hydraulic pump was an ambitious contract representing a state of art improvement over existing hydraulic pumps the majority of the Navy's long term RIW contracts have applied to the overhaul of existing equipment. Although the F-18 and LAMPS programs are considering the use of RIW both proposals have left it to the contractor to determine RIW candidates [Ref. 22].

L. COST EFFECTIVENESS OF RIW

To date only one completed RIW contract (the 1967 USN contract with LSI for maintenance of 800 gyroscopes) has provided comprehensive data concerning cost effectiveness.

During the initial economic analysis LSI projected a $780,000 cost savings for the Navy over the five year warranty period. This savings was based on reducing the maintenance cost of the warranted gyroscopes by 65¢ an hour. A total of 1.2 million operating hours was predicted over the warranty period [Ref. 26]. The cost savings were to accrue due to a 30% increase in MTBF over the five year period. LSI calculated that the cost per operating hour under RIW would be $2.79 which amounted to a $3.35 million fixed cost for the contract. The operating cost for unwarranted gyroscopes was $3.44 per hour or $4.13 million. The difference between the two figures ($4.13 - $3.35 million) represented the potential savings to the Navy. The minimum cost of the contract, was based on inducting 800 new configuration gyroscopes. In actuality a mixture of old and new units were inducted raising the contract cost to $3.766 million.

The contract, as mentioned previously, was at fixed cost and based on a total of 1.2 million operating hours. During the five year warranty period the Navy achieved only 85 percent of this operating hour total which had the effect of raising the operating cost per hour. Operating hours were less than projected due to a decrease in actual flight hours and a difference between the projected ground to air ratio (1.63) and the actual ratio experienced (1.47). Based on the reduced operating hour figure the Navy only broke even under this contract [Ref. 26]. A potentially

large savings may accrue to the Navy in the future because of the increase in reliability of the warranted gyros. These savings will be in the form of reduced repair costs and a reduction in the number of space gyroscopes required to support the installed units, however, actual data to evaluate these savings is not available at this time.

IV. CONCLUSIONS

Since the majority of long term RIW contracts have not completed their warranty periods, final evaluation data is lacking. Questions concerning cost savings to the government and profits to industry must wait for this data before they can be answered. Nevertheless, several conclusions can be drawn from the data that is available. RIW contracts have been used in the procurement of new equipment that has incorporated state of the art improvements over the old equipment that it was replacing as well as to overhaul contracts that have sought to improve the reliability of equipment already in the field.

The DDR&E and OSD(I&L) memorandum of 1974 urging the trial use of RIW seems to have achieved this objective. The Air Force, in particular, has negotiated an ambitious warranty contract for the AN/ARN-118 Tacan and is attempting to apply RIW in the procurement of the F-16 fighter. The Army has recently entered into a long term RIW contract for the procurement of new navigation equipment. The Navy's recent contract for the APN-194 Radar Altimeter represents a more conservative contract, however, the Requests for Proposals for the F-18 fighter and the LAMP's contain RIW provisions.

In all cases for which data is available the inclusion of a RIW provision in a contract has resulted in MTBF

improvement. The question of cost effectiveness, however, remains unanswered. The first Navy-LSI overhaul contract for the AJB-3 gyro resulted in a 30% increase in MTBF and a reduction in maintenance cost of 20% per unit. The Navy, however, did not realize the potential cost savings from the contract because of a decrease in operating hours which resulted in fewer failures and fewer repairs. Data from other contracts is lacking.

Several short term, 26 month or less, contracts that contained RIW clauses, have resulted in large MTBF improvements. Since these contracts are basically maintenance service contracts in that the short term of the warranty does not make no cost ECP's cost effective for the contractor, the large improvement in MTBF came from improvements incorporated in the equipment during design and production. The contractor was given the incentive to make these improvements since he could raise his profits by lowering the number of repairs he would make during the warranty period. By placing a larger emphasis on reliability and strictly enforcing reliability design specifications the same results could be obtained without the use of a RIW provision. Such an approach might prove less cumbersome and be more cost effective.

One major advantage of RIW is that it provides the contractor with timely and accurate data concerning the reliability of his equipment under field conditions. This

enables him to isolate the weak points in his equipment and correct them. This will also help him in any follow-on designs since he gets first hand experience with the operating environment. Another approach that provides this type of information is comparison of Target Logistic Support Cost to Measured Logistic Support Cost, one of the options in the F-16 contract. The total cost of this option is less than 50% the cost of the RIW option and less than 30% of the RIW with MTBF guarantee option. Although this option does not provide the contractor with an incentive to improve reliability over a long term period, it does provide for an incentive to keep logistic support costs low which translates to a high initial reliability.

Since all RIW contracts are for a specified operating hour or calendar time period the maximum cost savings to the government occur only when this operating time is achieved. An actual utilization rate below that projected will, at some point, make the RIW more expensive than organic maintenance.

In using RIW, the reliability of the entire weapons system must therefore be considered. In some cases, particularly with new weapons systems, it may be more advantageous to cover a wide variety of systems under RIW to insure an overall high reliability. An example of this type of application is the proposed F-16 application.

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

INSTALLATIONS AND LOGISTICS

14 August 1974

MEMORANDUM FOR The Assistant Secretary of the Army (Installations and Logistics)
The Assistant Secretary of the Navy (Installations and Logistics)
The Assistant Secretary of the Air Force (Installations and Logistics)
The Assistant Secretary of the Army (Research and Development)
The Assistant Secretary of the Navy (Research and Development)
The Assistant Secretary of the Air Force (Research and Development)

SUBJECT: Trial Use of Reliability Improvement Warranties in the Acquisition Process of Electronic Systems/Equipments - ACTION MEMORANDUM

Reference: (a) ASD(I&L) Memo to Secretaries of the Military Departments dated 17 August 1973: Subject: Trial Use of Warranties, etc.

As part of the Department of Defense's efforts to reduce costs and improve operational reliability of electronic systems and equipments, reference (a) requested that a trial application of warranties (now called Reliability Improvement Warranties (RIW)) be utilized in the acquisition process to help determine the scope and benefits that RIWs may have for the DoD. The objective of a RIW is to motivate and provide an incentive to contractors to design and produce equipment which will have low failure rates and low repair costs during field/operational use. This rechnique attempts, through the use of contracting agreements (which extend for several years after Government acceptance of the equipment) to provide an incentive repair costs in order to maximize their profits. Thus, the intent of the RIW contracting technique is to realize improved operational reliability and maintainability of DoD systems and equipments for each additional dollar that the contractor uses. For these reasons, a RIW is not a maintenance contract and therefore should not be used for this purpose.

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

As a result of reference (a), a Reliability Improvement Warranty Committee was established to prepare a definite OSD policy with regard to the application of RIWs in the procurement process. The committee membership includes representatives from the Office of the Assistant Secretary of Defense (Installations and Logistics), the Office of the Director, Defense Research and Engineering and the Military Departments. Valuable inputs have been provided by each committee member plus contributions by representatives from the Office of the Assistant Secretary of Defense (Comptroller) and the Office of the General Counsel. Mr. Donald F. Spencer from the Office of the Assistant Secretary of Defense (Installations and Logistics) has functioned as the Chairman of the Committee. The committee completed the RIW Guidelines on 12 July 1974. Included in the Guidelines are a RIW definition and scope, the RIW application criteria, the special funding requirements, the essential elements in a RIW contract clause, the RIW evaluation approach, and the potential benefits which may result from the use of a RIW. Thus, the Guidelines, enclosed hereto, are available for immediate use on a trial basis and should aid in determining whether potential economic and reliability benefits do, in fact, result. Therefore, the Military Departments are now requested to undertake a trial use of RIWs in a number of electronic system/equipment programs. These programs should be identified and their planned intended use of a RIW reported to the Office of the Assistant Secretary of Defense (I&L) WI (Attn: Mr. Donald F. Spencer) which will continue to function as the OSD coordinator for RIW activity.

To realize the maximum potential from the use of RIWs, it is important not only to identify the good results but also to identify the problem areas so that the latter can be factored in and corrected in the Guidelines. Particular attention should be given to the collection of data so that accurate evaluation can be made of each program. It is requested that quarterly status reports be submitted on the candidate systems.

A. I. Mendolia
Hon. Arthur I. Mendolia
Assistant Secretary of Defense
(Installations and Logistics)

M Currie
13 AUG 1974
Hon. Malcolm R. Currie
Director, Defense Research
and Engineering

Enclosure:
RIW Guidelines

RELIABILITY IMPROVEMENT WARRANTY GUIDELINES

DEFINITION AND SCOPE

One of the most significant items of continuing concern to the Department of Defense is the need for improved reliability and maintainability 1/ of our weapon systems' equipment.

A contractual technique used in the commercial environment and currently being utilized on a trial basis within the DoD as a means of implementing such improvements is the Reliability Improvement Warranty, or RIW (also previously known as a "Failure Free" or "Standard" Warranty). The objective of a RIW is to motivate and provide an incentive to contractors to design and produce equipment which will have a low failure rate as well as low repair costs, after failure due to field/operational use. Furthermore, this technique attempts, through the use of contractual agreements (where the period of performance extends over several years), to provide an incentive for contractors to improve the reliability of their equipment and to reduce repair costs during the period of warranty coverage in order to maximize their profits.

It should be noted that a RIW is not a maintenance contract and does not require that the contractor provide routine periodic upkeep, regulations, adjusting, cleaning or other normal upkeep. A RIW also does not cover

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1/ "Maintainability" refers to a design feature of a system, subsystem, equipment or component which connotes that the item is subject to being repaired and maintained in an established environment, under defined operating conditions, and within set time and cost restraints needed to meet established reliability requirements. "Maintainability" does not define maintenance or repairs, but rather, the ease with which they may be accomplished.

components of a warranted item which are expected to need replacement under normal use during the term of the warranty (such as filters, light bulbs, etc). Such items may be provided for by separate provisions in the contract consistent with current laws and regulations, but they shall not be included in the RIW provision. In general, a RIW will provide for the repair or replacement of failed units as well as agreed to no cost engineering changes and the calibration, adjustment and testing associated therewith.

The Armed Services Procurement Regulation (ASPR) states that a warranty clause gives the Government a contractual right to assert claims regarding the deficiency of supplies or services furnished, notwithstanding any other contractual provisions pertaining to acceptance by the Government. Such a clause allows the Government additional time after acceptance of these supplies or services in which to assert a right to correction of the deficiencies or defects, re-performance, an equitable adjustment in the contract price, or other remedies. This additional period of time may begin at the time of delivery, or at the occurrence of a specified event, and may run for a given number of days or months or until occurrence of another specified event. The intent of such a clause is "buyer protection" from non-conforming materials or poor workmanship. The RIW goes beyond this conventional concept of warranty.

The essence of the RIW philosophy is that during the period of the warranty coverage, for a fixed price, contractors will be encouraged to improve the reliability and to reduce the repair costs of the equipment through the mechanism of "no-cost" (to the Government) Engineering Change Proposals (ECPs). These ECPs shall be consistent with Government procedures to preserve Configuration Control. Once a fixed price is established for the warranty, the actual profit realized by the contractor is dependent upon the equipment's reliability and maintainability in service use, plus any improvements that he can make in its reliability and maintainability so as to keep the number and cost of repairs as low as possible. A RIW results in the contractor focusing his attention on his reliability and maintainability efforts, since through such a program he can obtain greater profit. Thus, a RIW becomes a contracting technique by which the Government derives the benefits of improved reliability and maintainability for each additional dollar that the contractor earns. The above features therefore distinguish a RIW from the conventional warranties described in ASPR.

The RIW concept may be introduced at any point during the acquisition cycle. Normally, the maximum benefit can be expected by including such a RIW contract provision at the time of award of the initial production contract for the system/equipment. For new equipment, it will generally be appropriate for the Government to indicate to prospective contractors

early in the development cycle that it plans to consider such a warranty provision for inclusion in the contract at the time of initial production approval. By so doing, contractors will be motivated to ensure that their equipment's reliability and maintainability are given appropriate attention at the time it is initially designed, since this could affect its subsequent repair or replacement costs.

The greatest value of a RIW contract provision is expected to be realized in the initial years of the equipment's field deployment. Thus, after the equipment's reliability and maintainability have been satisfactorily demonstrated through field use, the Government may then assess the cost effectiveness of the RIW to determine whether to continue or to eliminate such warranty coverage. It should be emphasized that the terms and commitments required of the contractor, particularly for the initial warranty, should result in a reasonable balance between his risks and the degree of incentive needed to achieve the primary goal of system availability. The size and scope of the initial commitmen should be determined in consideration of the uncertainities in future support costs and the risks involved to both contractor and government. This period of warranty coverage generally will continue for at least three years.

RELIABILITY IMPROVEMENT WARRANTY (RIW)

A Reliability Improvement Warranty is defined as a provision in either a fixed price acquisition, or fixed price equipment overhaul contract in which:

(a) the contractor is provided with a monetary incentive, throughout the period of the warranty, to improve the production design and engineering of the equipment so as to enhance the field/operational reliability and maintainability of the system/equipment; and

(b) the contractor agrees that, during a specified or measured period of use, he will repair or replace (within a specified turnaround time) all equipment that fails (subject to specified exclusions if applicable).

A fixed price for the RIW coverage should be agreed upon during negotiation of the acquisition contract or equipment overhaul contract. The warranty should also be established as a separate contract line item. In the case of formally advertised contracts, the terms of the warranty and a separately priced contract line item must be provided for in the Invitation for Bids.

RELIABILITY IMPROVEMENT WARRANTY (RIW) APPLICATION CRITERIA

Decisions for RIW application should be made as early as possible in the acquisition cycle. The contractor should be informed early in the design phase that there will be warranty requirements so that he can make important trade-offs. It is noted that the equipment need not meet all the criteria shown below in order to apply a RIW. Rather, at this point in time the Government should pick logical candidates which meet several or many of the criteria so that further assessment can be made of the value of this technique.

The following criteria may be used for selecting equipment as potential candidates for Reliability Improvement Warranty coverage. These criteria may be used for systems, subsystems, units, subunits, or even modules.

a. A warranty can be obtained at a price commensurate with the con-

b. Moderate to high initial support costs are involved.

c. The equipment is readily transportable to permit return to the vendor's plant or, alternatively, the equipment is one for which a contractor can provide for field service.

d. The equipment is generally self-contained, is generally immune from failures induced by outside units, and has readily identifiable failure characteristics.

e. The equipment application in terms of expected operating time and the use environment are known.

f. The equipment is succeptible to being contracted for on a fixed price type basis.

g. The contract can be structured to provide a warranty period of several years. This should allow the contractor sufficient time to identify and analyze failures in order to permit reliability and maintainability improvements.

h. The equipment has a potential for both reliability growth and reduction in repair costs.

i. Potential contractors indicate a cooperative attitude toward acceptance of a RIW provision and evaluation of its effectiveness.

j. A sufficient quantity of the equipment is to be procured to make the RIW cost-effective.

k. The equipment is of a configuration that discourages unauthorized field repair, preferably sealed and capable of containing an Elapsed Time Indicator (ETI) or some other means of usage control.

l. There is a reasonable degree of assurance that there will be a high utilization of the equipment.

m. The equipment is one that permits the contractor to effect no-cost ECPs subsequent to the Government's approval.

n. Failure data and the intended operational use data can be furnished the contractor for the proposed contractual period and updated periodically during the term of the contract.

FUNDING OF RELIABILITY IMPROVEMENT WARRANTIES

In the past, different points of view have been expressed regarding the funding of RIWs. Lack of clear guidance in this area has caused difficulties in the use of this contractual technique. In order to provide clarification regarding the types of funds to be used for procurements incorporating a RIW, the funding policy guidelines have been authorized for use by OASD (Comptroller) and Office of Assistant General Counsel(FM). These funding guidelines should permit the more effective utilization of RIWs.

a. RIWs shall be funded from the same appropriation as the acquisition or overhaul warranted (i.e., the warranty shall be paid from the procurement, operation and maintenance, or RDT&E appropriation of the service or agency concerned depending on from which of the said appropriations the acquisition or overhaul is funded). The RIW cost is part of the fixed price contract, and payment to the warrantor for the RIW portion shall not be made in a manner different than payment under the remaining portion of the contract, except that, payment for the RIW may be delayed until delivery or relinquishment of control of the item by the warrantor.

b. In order to maintain the important distinction between a RIW and a service contract covering normal, periodic maintenance, the following requirements must be satisfied:

(i) The RIW shall be included in a fixed price contract for the acquisition or overhaul of an item or items.

(ii) The warranty period on each item shall begin after manufacture or overhaul, upon delivery or relinquishment of control of the item by the warrantor.

(iii) The RIW shall require the warrantor to repair or replace the warranted item upon failure.

(iv) The RIW shall not include requirements for the warrantor to provide normal upkeep, cleaning, adjusting, regulating or other periodic maintenance which would be required without respect to failure.

(v) The RIW shall exclude components of the warranted item which under normal circumstances will require replacement before the expiration of the warranty (such as filters, light bulbs, etc.). Such items may be provided for by separate provisions in the contract consistent with current laws and regulations, but they shall not be included in the RIW provision.

ESSENTIAL ELEMENTS IN RIW CLAUSE

Because RIW provisions must be tailored to the item selected, a standard RIW clause is not feasible. However, the following is a list of those essential elements which normally should be considered for inclusion in such a clause:

I. STATEMENT OF CONTRACT WARRANTY

a. TERM. State length of time warranty will be in effect. This should cover usage (operating hours)and/or calendar time (generally three years or longer).

b. OBJECTIVE/SCOPE: State the primary objective of the warranty, i.e., to motivate the contractor to design and produce equipment which is more reliable and less costly to repair than at present. If there is to be a specified reliability requirement, this should be clearly set forth in the contract.

c. FAILURE: State what constitutes a failure which will require the contractor to repair or replace a failed item, at his option, at no change in contract price.

d. EXCLUSIONS: State what conditions (e.g. items lost or damaged due to fire, explosion, etc.) and actions associated with repairs (e.g. packing shipping, etc.) are specifically excluded under the warranty.

e. SHIPPING COSTS: State if contractor or Government pays for expense of returning failed units to contractor.

f. PRICE: Indicate a separate price for warranty coverage and for the basic unit procured in order to make it possible to determine the cost to the Government of the RIW.

II. CONTRACTOR OBLIGATION

a. WARRANTY MARKINGS. Require contractor to cause prominent displ. of pertinet information on surface of unit, showing that item is warranted, warranty period, actions to take if unit fails during warranty period, etc.

b. TURNAROUND TIME: State turnaround time required by the contract and contractual adjustments or other considerations, as appropriate, to be exacted if the contractor exceeds the number of days so specified. A contract turnaround time should be defined as date unit is received by contractor for repair, to date unit is repaired and shipped by contractor to Government.

c. RECORDS: Require contractor to maintain records by serial number for each unit under warranty and to make such records available to the Government upon request.

III. GOVERNMENT OBLIGATION:

a. CONTAINERS: Indicate whether or not the Government will supply special containers for reshipment of units to and from their destinations for the life of the warranty.

b. NO-COST MODIFICATIONS: State procedures for submittal of contractor initiated no-cost ECPs designed to improve the unit's reliability/maintainability. The contractor should be advised that such ECPs will be subject to the Government' approval.

IV. MISCELLANEOUS

a. INSPECTION: State the extent of both Government and contractor inspectio: to be required.

b. DISPOSITION: State that each unit returned, that is not considered repair-able, shall be disposed of by the contractor as directed by the Administrating Contracting Officer (ACO). Also, indicate the manner of disposition of the unused portion of the warranty for any unit subjected to an excluded failure or that, upon certification by the ACO, is declared lost.

c. NOTIFICATION: Indicate the requirement for both the contractor and the Government to notify each other, within a specified time, of any deficiency discovered in a unit.

d. UNVERIFIED FAILURES: State whether or not the contractor will be compensated for the cost of testing items returned to him under the warranty for which no discrepancy is found.

e. ADJUSTMENTS: Indicate under what circumstances, if any, the Government is authorized to make adjustments to units under warranty.

V. DATA REQUIREMENTS

a. WARRANTY DATA: The contractor will be required to establish and maintain a data system capable of providing a repair record of each unit, analysis of unit failure, number of items returned, turnaround and pipeline time of unit returned, remaining warranty coverage, etc.

b. GOVERNMENT DEVELOPED DATA. The Government shall be required to provide in a timely manner, available Government generated operation and maintenance data generated on the equipment.

DETERMINATION OF COST EFFECTIVENESS OF USE OF A RELIABILITY IMPROVEMENT WARRANTY

The benefits to be derived from use of a RIW provision should be related to the cost thereof to the Government as well as system reliability and availability. In the case of new systems and equipment entering the Government inventory which are not similar to existing equipment, the Government will have no direct

experience with such items for a baseline cost. Therefore, to compute benefits versus warranty cost, in the above instance, may require judgment on the part of the Government.

In general, a cost analysis should be performed for each proposed warranty application, upon receipt of the contractor's proposal, in order to determine whether or not use of a RIW would be cost effective. Such an analysis should investigate the relative cost of the RIW and non RIW situations (including ECPs) and examine the cost of varying time periods. The use of a RIW provision will generally involve additional costs over the acquisition cost. These costs must be compared with "in house" Government costs to perform repairs and make equivalent reliability improvements.

The decision to accept or reject a RIW provision must, therefore, be based in part on the support costs the Government would incur if the equipment were purchased without a RIW. The Government support organization would have to provide a cost estimate to do the things that the contractor would do under the RIW.

In order to make an accept/reject decision as to use of a RIW provision, the actual price proposed by the contractor for the RIW must be known. It is therefore important that the contractor be required to separately price the RIW provision so that a comparison can be made with the Government estimate.

RELIABILITY IMPROVEMENT WARRANTY EVALUATION APPROACH

In evaluating the effectiveness of the RIW approach from a cost and performance viewpoint, it is essential that accurate data be gathered on field reliability and

utilization plus maintenance actions and that the contractor be cooperative in reporting actions taken under the warranty. Both the Government and the contractor must establish and maintain a data system capable of providing information relative to warranted equipment so that a suitable evaluation can be made.

It would be most desirable to determine how effective the RIW approach has been when compared with identical or similar equipment whose repair was accomplished by a Government repair facility or by separate contract; however, this may not be possible in many instances. Thus, when an item under warranty is being produced for the first time or, when there is no identical or similar non-warranted equipment available for comparison, it will be necessary to compute what it would have cost the Government repair facility to do the job if there had been no warranty provision in the contract, based on the failure rates actually experienced, time to repair, number of spares required, etc. This method of comparing estimated Government repair facility costs with the contract price paid for the warranty is one of the few methods available to evaluate the relative cost of the warranty approach where a control group is not present.

In assessing whether or not the RIW approach used in a given procurement has increased reliability, ease of maintenance, and the service life of the equipment from both an acquisition and a repair and overhaul basis, we must ensure that sufficient usage data is available under the contract to enable a proper analysis to be made. In other words, a significant portion of the contract warranty must be completed, with respect to expended hours, so that a definite

trend has been established. This is especially important since there is a possibility that benefits commensurate with the price paid for the warranty may not materialize because of a reduction in the use of the equipment under that contracted for in the warranty provisions.

Factors to consider in evaluating RIW results (pertaining mainly to equipment for which we have operational experience) in order to make a determination as to the scope and benefits to the Government due to use of a RIW provision are as follows:

a. Number of operational units procured.

b. Price of basic unit as well as price paid for warranty coverage.

c. Warranty period in months.

d. Operating hours used per month, as well as total program operating hours involved.

e. The planning MTBF that the warranty was based upon, as well as the number of returns planned on during the warranty period.

f. In the case of new equipment buys, the amount of savings estimated in initial Government support costs by precluding the need for such support items as test and support equipment, training of Government personnel and technical manuals. However, in determining the savings involved, care should be taken that if the Government expects to assume support after the warranty expires, "start up" costs should be included.

g. Government recurring support costs, such as the cost of warranty administration. For example, maintenance and supply personnel must be

trained in handling and shipping warranted units so as not to void the terms of the warranty. Furthermore, the special data requirements of warranty clauses will also require administrative action.

h. Number of spare units required due to excessive contractor turn-around time, and cost thereof to the Government.

i. Comparison of cost of organic repair (processing through Government depot repair facility) of unwarranted items with repair costs for same items under warranty.

j. Comparison between contract price for RIW coverage (for the hours of operation contracted for under the warranty provisions), with the repair expense based on acquiring the same number of operating hours from an unwarranted unit.

k. Comparison of MTBF, turnaround and pipeline time of the warranted items with that for unwarranted similar items and the effect thereof on availability of equipment to the Government.

l. The extent to which any improvement in the MTBF, turnaround and pipeline time of the warranted equipment may be attributed to the RIW contract provisions.

m. If there is a reduction in the use of the equipment under that contracted for in the warranty provisions, whether or not this has resulted in benefits not being commensurate with the price paid for warranty coverage.

n. Any reduction in cost associated with relaxation of configuration control, quality assurance and reliability tests.

OTHER PROCUREMENT RAMIFICATIONS

A principal motivation for RIW is to provide an incentive for the manufacturer to be responsible for the field reliability (rather than laboratory or bench reliability) of his equipment and encourage him to modify the equipment as needed to achieve reliability improvements.

In the absence of such an incentive the government has traditionally relied on a number of specifications and standards for configuration management, quality assurance, reliability demonstration and parts and fabrication procedures in an attempt to enforce the production of reliable and maintainable equipment. For each procurement for which a warranty is planned, a review should be made to insure that procedures and specifications are not applied in such a manner as to increase inherent costs or to reduce contractor opportunities to make cost savings.

POTENTIAL BENEFITS FROM USE OF RELIABILITY IMPROVEMENT WARRANTIES

Many potential benefits to both the Government and the contractor may result from the use of RIW provisions. Some of these benefits are as follows:

BENEFITS TO GOVERMENT

a. Incentives and responsibility for field reliability are assigned to the contractor.

b. Greater emphasis is placed on the life cycle cost approach.

c. The contractor is responsible to keep all units up to the same configuration.

d. There is an increased incentive for the contractor to introduce design/production changes that will increase the MTBF of the equipment and result in reliability growth.

e. An incentive for reduction in repair costs is provided, since any reduction in labor hours or materials used in repairing equipment will increase the contractor's profits.

f. Minimal initial support investment is required by the Government, since the contractor is to provide repair services during the warranty period.

g. RIW usage may reduce requirements for skilled military maintenance and support manpower.

BENEFITS TO CONTRACTOR

a. Increased profit potential when field MTBF is improved above pricing base.

b. Multi-year guaranteed business.

c. The contractor becomes more familiar with the operational reliability and maintainability characteristics of his equipment, which should help him in obtaining follow-on contracts.

CONCLUSION

In conclusion, a Reliability Improvement Warranty is a procurement approach which, when properly applied, can reduce the Government's life cycle costs. Inherent in the RIW concept is the contractor's motivation to continuously reduce repair or replacement life cycle costs through reliability

effort applied beyond hardware acceptance. Due to the continuous stress by the contractor on decreasing failure rates, the Government benefits through better equipment availability.

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

INSTALLATIONS AND LOGISTICS

16 SEP 1975

MEMORANDUM FOR Assistant Secretaries of the Military Departments (R&D)
Assistant Secretaries of the Military Departments (I&L)

SUBJECT: Reliability Improvement Warranty (RIW) Guidelines

References: (a) ASD(I&L) Memorandum to Secretaries of the Military Departments, dated 14 August 1974, regarding Reliability Improvement Warranty (RIW) Guidelines.
(b) Council of Defense and Space Industry Associations (CODSIA) Letter, dated 18 July 1975, regarding RIW's.

The purpose of this memorandum is to clarify and expand on DoD's current RIW Guidelines. Your support in continuing to see that reliability incentives are properly applied to contracts is essential to reduce support costs and improve field reliability. This is especially important in light of the recent concerns expressed by industry that RIW's may be inappropriately applied so as to pose undue risk on contractors (reference b, enclosure 2, the issues raised therein will be investigated by a recently formed tri-Service working group).

We wish to re-emphasize that the principal objective in applying RIW's is to incentivize contractors to design and produce reliable equipment. Imposition of unreasonable terms and risk on contractors will not serve this objective.

The RIW objectives can be best achieved under a fixed price contractual agreement. Other incentive approaches for improving equipment reliability should be utilized when application of a RIW would result in undue risk. A recently established "Tri-Service Reliability and Support Incentives Group" will in the next four months investigate other contract incentive techniques and develop guidelines for these concepts. Your support of this group's efforts is requested.

Two major criteria for the application of RIW's are that: (1) the field reliability, costs to support the equipment, and potential for reliability growth will be reasonably predictable at the time the firm fixed price bid is made, and (2) the terms of the RIW be tailored so that the rewards and risks to both industry and the government are acceptable. These criteria are discussed in enclosure 1.

The above criteria should be disseminated as a clarification and expansion to the current RIW guidelines. Procuring agencies should be instructed to apply the two preceding criteria. For each RIW application an independent analysis should be performed to determine that contractor bids are reasonable and that there is a proper balance between potential rewards and risks.

Proper application of the above guidelines will contribute to the wider use of warranties on a sound basis.

Acting Assistant Secretary of Defense
(Installations and Logistics)

Enclosures

Phyllis

APPLICATION OF RIW's

MAJOR CRITERIA for application of RIW's are:

1. Field reliability, costs to support the equipment, and potential for reliability growth will be reasonably predictable at the time the firm fixed price bid is made.

2. Terms of the RIW be tailored so that the rewards and risks to both industry and the government are acceptable.

For RIW application to have maximum affect, contractors should be told early in development that a warranty is anticipated. It is desirable to elicit a warranty quote during the competitive phase in order to get a reasonable price. This raises the problem that the quote may be solicited prior to the completion of development testing and with associated uncertainties. As a general rule, the price quote should be solicited as late in the program as possible, under competition, and consistent with the needs for test data associated with each program.

There are a number of criteria which should be satisfied for a program to be selected for RIW application, examples of which are contained in the current RIW guidelines. A major criteria which should be emphasized is reasonable risk to industry as well as to the government. Such is significantly influenced; (1) by whether the equipment is evolutionary, (2) by the availability of test data (at the time of bid) on which to base cost and reliability estimates, and (3) by the ability of the government to provide the contractors with reasonable projections of mission, environment, and expected utilization.

Application of RIW's does not have to be limited to procurements that are merely a repackaging of previously fielded equipment. It can be applied to any new equipment, even if the design utilizes new technology and there is no previous field experience. What is important is that adequate development time and testing be scheduled to support reasonable cost and reliability estimates at the time the firm fixed price bid is made.

For any RIW application, considerable latitude exists in tailoring the terms and conditions to the uncertainties. For example, the reliability guarantee can be tailored; turn-around time requirements can be varied; exclusions can be adjusted to fit the situation; and the initial commitment can be limited to the initial production buy. In general, the greater the uncertainties the less stringent would be the warranty terms. In no case, however, should terms be tailored to such an extent that the RIW objective of improved field reliability and reduced support costs are no longer incentivized.

APPENDIX B

CODSIA REPORT

TO

Brig/Gen. Dewey K. K. Lowe

Director of Procurement Policy,

DCS/Systems & Logistics, Hq. USAF

ON

"RELIABILITY IMPROVEMENT WARRANTY - KEY ISSUES"

April 23, 1976

I. TIMING OF RIW APPLICATION:

A. When Should RIW Be Applied?

In addressing the question of "when" RIW should be applied, consideration must at the same time be given to "how" it should be applied, and also to pertinent background and historical factors relating to reliability, from the laboratory and field usage vantage points. Fundamentals of contractor and government risk must also be addressed.

o   Background

Industry is keenly aware of, and quite sympathetic with, the USAF need for improved field reliability and feels that one route to the achievement of that goal may be a properly applied RIW program. The current change in emphasis from "performance at almost any cost" to a desire for a proper balance of performance, unit production cost, reliability, maintainability, and availability is also well recognized and applauded. In achieving this balanced emphasis on reliability and lower operating costs the USAF has felt the necessity to provide an early incentive which will help insure proper emphasis on lower operating cost (i.e., reliability and maintainability) during the critical design and development period. *It is during this period that* the greatest impact on eventual field reliability will be realized. The problem of high operating cost and associated low availability resulting from poor field reliability and maintainability is not new.

While it is true that performance has been the overriding factor in *former years, the reliability question* was not entirely ignored. The initial approach was to specify a required MTBF in the procurement spec. Laboratory tests in a benign environment were carried out to demonstrate that the specified reliability had been achieved. Later an attempt was made to simulate the ambient environment during these laboratory tests, and finally, reliability growth testing was instituted during the laboratory reliability test cycle. That these techniques did not achieve the desired results in the field is evidenced by the chart on page 10. This chart plots the reliability achieved in the field against the specified reliability for ten different tactical radars in as many varieties of aircraft. All of the various previously discussed techniques for measuring reliability in the laboratory are represented in this sample. Presumably, the laboratory tests approximated the specifications before commitments to full scale production were made. It is, therefore, obvious that those techniques did not solve the real problem of reliability in the field.

There is little doubt that the USAF faces a real problem if a means of reversing this trend of low field reliability and resultant high operating and maintenance cost is not found. According to highly qualified DoD sources, fifteen years ago 50% of the USAF budget was expended on investment in new equipment and 50% on O&M and pay. Today, 30% is spent on investment and 70% on O&M and pay. Unless this trend is reversed, the consequences to the USAF, industry, and the nation will be indeed serious.

The USAF desire to introduce the RIW concept quite early in the development cycle of a program and thereby provide the incentive to motivate

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the contractor to consider field reliability on at least an equal footing with unit production cost and performance is quite understandable. CODSIA agrees, and the potential differences of opinion relate only to the technical methods and contractual implementation by which this objective is to be accomplished.

6 Reasonable Predictability and Risk vs. Traditional Reliability Test Methods

Industry feels that the requirement for Firm Fixed Price (FFP) RIW quotations or options on production articles prior to completion of the development cycle is an unsound procurement practice for both government and industry. Until the hardware is tested in an operational environment, with typical operational users, and in all planned vehicles/platforms, etc., reliability (the basis for a good RIW quote) is not "reasonably predictable".

This is especially true in today's technological environment where very rapid changes are the order of the day. In the avionics arena for example, we have, in the last 15 years, progressed from largely thermionic devices to discrete solid state technology and on to integrated circuitry. Integrated circuits themselves have rapidly gone from rather simple devices to medium scale integration, and on to large scale integration. Meanwhile system concepts have changed from utilizing largely analog interfaces to today's reliance on digital interfaces.

All of this technological advancement appears to be moving in the right direction to greatly improve reliability over that of earlier generation equipment and the reliability predictors are postulating this to be the case. Caution is urged, however, since in the past reliability predictions have seldom if ever matched field reliability numbers, even where similar technology has been previously fielded. The accuracy of the predictions is even more questionable when the technology involved has not had the benefit of a valid comparison between actual field results and prediction.

When the concept of reliability growth testing was conceived (i.e., the test-fix-test-fix philosophy) it was advanced as a means of arriving at a high level of reliability during the development cycle; a level which would translate into field reliability with little or no degradation. Actual field experience has not borne out these optimistic expectations.

One tactical radar, for example, was subjected to the type of testing outlined above for a total of 8484 hours in the factory. Under this testing which involved some 54 systems, an MTBF of 161 hours was achieved at the 90% confidence level. It should be noted that these tests were conducted in a MIL-STD-781 environment.

Several years later, these same radars exhibited a reliability of only 26 MFHBF (Mean Flight Hour Between Failure) on one type of aircraft and 33 MFHBF on another type of aircraft according to USAF 66-1 data collection system. This represents a degradation of about 5 to 1 over the laboratory test results which illustrate the uncertainty involved in predicting field MTBF based on laboratory results.

This example should not be taken as a condemnation of the reliability growth test philosophy however, since this system exhibited a field reliability about 3 times that of similar systems which had not been through this experience.

This example is not an isloated case. Another contemporary tactical radar which received much emphasis on reliability during development, including reliability growth testing, again exhibited a degradation of about 4 to 1 from lab to field. Other examples have been noted where degradation as high as 15 to 1 have been experienced.

It should be obvious, therefore, that a FFP RIW quote prior to full scale development is inordinately risky. Further a FFP RIW goal based on laboratory testing and prior to operational testing is not a viable alternative.

While the risk involved in predicting the operational MTBF (the basis for a RIW quote) is *certainly greatest in newly developed equipment*, a substantial risk is still present when equipment is "simply" redesigned, repackaged or even utilized in a different type of vehicle. Redesigning or repackaging may sufficiently alter cooling, vibration and shock modes, operator involvement, etc., in such a way as to grossly affect field MTBF. Simply moving the equipment from one type of vehicle to another may alter the environment and appreciably affect the reliability.

An obvious example would be the use of 66-1 data taken on a navigation system in a transport aircraft and using it to predict the reliability of that same system in a fighter aircraft. It should be stated that the 66-1 data in itself is subject to some question as an accurate measure of field reliability since its validity and accuracy are affected by such factors as retest OKs, consequential failures, lack of good failure mode data, and operator-and-maintenance-induced failures resulting from the inexperience of organic field maintenance teams, and/or operator-users.

In addressing the general subject of risks involved with the RIW concept, it is a fact that very little actual experience exists in the use of RIW by the military. It appears that only two USAF programs have provided some limited experience.

It would appear that with the scant amount of RIW experience at hand, it would be well to proceed slowly and cautiously on RIW until a larger data base is available.

In summary, the USAF motivated by valid concerns, would prefer an early industry commitment to RIW. Industry understands this preference but fears the risk involved in such a commitment, as exemplified by several recent significant procurement implementations. Happily, however, we believe this USAF/industry dichotomy can be resolved to the satisfaction of both partied by a contractual technique of progressive application of RIW. This technique would vary somewhat depending on the type of program involved.

B General Approach and Rationale

In situations involving the design/development/[illegible] cycle, an RIW cost goal (similar to a unit production cost [illegible]) would be set early. A meaningful or positive incentive would be tied to the later achievement of that goal. Depending on the type of program involved, the incentive would be monitory or continue participation in the program. In any event, the development and early production phases must include expanded development laboratory and field reliability testing with adequate time and funds to accomplish this testing. It is particularly important that the Government be prepared to allow the cost of adequate component testing and development (as a separate contract line item where appropriate) such that design tradeoffs can be made early and on the basis of empirical data.

A properly applied RIW should have two favorable impacts on reliability; (1) during the critical design, development and test phase of a program, RIW should provide the opportunity for a practical and achievable incentive to the contractor under a CPIF form of contract to build reliability and maintainability into the hardware and (2) after the equipment is operational, RIW should provide an incentive for continued reliability improvement. This latter improvement is achieved through a properly applied firm fixed price type RIW contract, (i.e., after field-validated test results are in hand) under which the contractor must balance the cost of continued repairs against the cost of reliability improvement changes. In order to reduce his total cost under the RIW it is anticipated that the contractor will indeed make field changes which will incrementally result in improved reliability.

Of these two impacts on reliability, undoubtedly the greatest potential impact is achieved during the design, development, and test phase of a program. For this reason the USAF has, in some recent procurements, requested FFP RIW options at a program milestone prior to full scale development (FSD) of hardware.

On the other hand, industry considers the risk associated with the premature (i.e., pre FSD & operational test) commitment to RIW on a FFP basis to be unduly high. This is particularly true where new development is involved, however, repackaging or use in a different application may render historical reliability data invalid.

A resolution of this dichotomy would be to establish RIW goals only during the development program tied to a realistic incentive if the goals are met. The development acquisition cycle should include a test of production type hardware in an operational environment, during which test field reliability would be measured. The incentive should be based on how well these test results match the development goals and the FFP RIW quote would also be based on the results of this test.

Achievement of the developmental RIW goal would be measured against actual performance of pilot production hardware (or preproduction prototype hardware if the task is considered to be an expansion/extension of the development phase) in the operational use environment.

The FFP RIW would be quoted at the termination of the operational test period and would utilize contractor-acquired and analyzed field failure data accumulated during this test. Incentive payment would also be based on how well the development goal matched the actual performance in the operational test. It is believed that a development program structured as outlined above would reduce the risk to a manageable level.

Procurements which involve only production of additional quantities of hardware which had been previously fielded may be amenable to FFP RIW without the test phase outlined above. This application does not offer optimum utilization of RIW however since it comes too late in time to influence reliability during the development/design phase. Only the results of the reliability growth phase of RIW could be realized.

o Specific Approaches

In any event, the detailed mechanics of applying the proposed RIW plan will vary somewhat depending on the type of program involved. Three types of programs will be considered for more detailed discussion.

1. Parallel Development Program

A. Parallel development program is defined as one in which two or more competing suppliers are carried through full scale development and at least up to the production decision point (DSARC II).

In such a program, it would be assumed that the USAF, in using RIW, would be interested not only in the lowest possible O&M costs but also in achievement of the lowest Life Cycle Cost (LCC). RIW, then, is a means of bringing more realism to the costing of the operational phase of the program's life cycle.

In the parallel development program, goals for total Life Cycle Cost would be set at the beginning of the program. The competitors would then be encouraged to trade off unit production cost goals against

support cost goals including an RIW goal (repair cost) in order to arrive at the lowest LCC. Competition will insure that the RIW and unit production cost goals are optimized for USAF requirements. The development phase would then be expanded to include field tests of all competitors hardware using either preproduction prototypes or pilot production hardware built for this purpose. In any event, the hardware used in these tests would be built to production drawings and with production tooling. The tests would be conducted in an actual operational environment and using operational type personnel. The results of those tests would assure the USAF of the realism of the competitor's reliability claims and would at the same time reduce the risk associated with the FFP RIW quote for industry. No incentive is more powerful at this stage than the desire on the part of the competitors to win the production award. The USAF would then obtain more realistic (i.e., contingency-free) FFP RIW quotes from the competitors, and would buy production hardware with RIW from the supplier offering the lowest LCC.

Using the above technique, the risk associated with FFP RIW would be reduced to a manageable level for industry while at the same time, the USAF would be assured by the competition of a reliable design with the lowest practical RIW cost. The use of parallel development is highly recommended wherever possible.

Although this technique requires a larger cash outlay initially, it would no doubt result in the lowest life cycle cost in the long run. It is recognized, however, that the initial outlay of large development funds is often viewed with a jaundiced eye by RDT&E fund custodians, Congress and others in the approval cycle. Nevertheless this outlay, in our judgment, must be regarded, not as out-of-pocket expense, but rather as investment in the future, with gains to be realized and measured in terms of enhanced equipment availability and lowered O&M costs.

2. Competitive Single Development Program

The competitive single development program is defined as one in which competition exists only through the early stages but not to full scale development. Because of the difficulty in obtaining the large outlay of front end money associated with parallel development, this is the type of program most frequently encountered in major weapons system programs.

With the competitive single development program, RIW goals would be set early and would emphasize the importance of reliability and Life Cycle Cost during the critical design and development phase. In this type program, the realism of these goals would be insured by applying a significant monetary incentive (not penalty) to the achievement of the goal.

As in the case of parallel development, preproduction prototypes built to production drawings and tooling or pilot production articles

would be subjected to the field reliability test described previously. Again the field test would be carried out in an operational environment using military personnel.

The FFP RIW quote would utilize the operational MTBF determined by the above test results. Using the same test results, the RIW incentive payment would be based on the relationship between the goal established early in the program and the FFP RIW established above.

With this technique, the USAF desire to introduce the RIW concept early enough to influence the design would be satisfied, while at the same time, industry's risk would be reduced to a manageable level.

3. Competitive Production Program

Let us consider two instances of a competitive production program:

(a) In the first instance it is defined as a competitive procurement of additional quantities of an article already in production and already fielded.

(b) The second definition of a competitive production program is one in which there is a multi-source competition for the production of an article developed by one firm but not yet developed into operational use. We do not recommend the application of RIW to either of these programs for a number of reasons, the most significant of which are:

1.) In the first case the potential for reliability growth would be limited and configuration control management would offset savings, and, in the second cited instance,

2.) Complex hardware, while lending itself to RIW by the developer does not provide adequate data to the competition to constitute a reasonable risk.

4. Definition of "Development" from a Technology Viewpoint

For the purpose of RIW, "development" is simply defined as any program resulting in hardware sufficiently different in form, fit and function from previously developed/deployed hardware as to require a formal design and/or environmental qualification test program prior to the device becoming operational.

This definition then applies not only to hardware involving new advanced technology and concepts, but could also encompass the following:

(a) Redesigns of existing hardware to modernize the circuitry (i.e., change from vacuum tube or discrete component circuitry to integrated circuitry).

(b) Mechanical repackaging to change the form factor for a new application.

B. Options

The FFP RIW option is a firm commitment, and should be quoted only when the MTBF/RIW Cost is "reasonably predictable" as previously described. On programs involving development this occurs only after reliability data has been accumulated from operational tests and analyzed by the contractor.

1. Selective Exercise

Two definitions of "selective exercise" have been considered. The preferable definition is one in which the seller is asked to quote FFP RIW options for successive FY buys of equipment after completion of the operational tests previously discussed. Industry has no objection to use of such options provided that, in consideration of technical and economic factors, the price for the options is subject to redetermination and adjustment at successive periods to be set forth in the contract.

The second definition of "selective exercise" involves the case where the buyer is permitted to apply RIW selectively to portions of the equipment under procurement. This represents a situation which is unsatisfactory to industry since:

(a) It presupposes commitment prior to the availability of field MTBF data, and

(b) It may permit the buyer to select only the low reliability portions of the equipment for the RIW. Thus, while the equipment as a whole may exhibit quite satisfactory reliability, the supplier is saddled with maintenance cost of the less reliable portion. It would also seem that this would be undesirable from a government viewpoint because of the elimination of hardware items whose field reliability could be improved through RIW.

2. Exercise Restrictions

As outlined above, options should not be required until field reliability data is available. The exercise of options should be restricted to purchase of RIW for successive FY buys of production hardware only.

C. How Long a Warranty

The warranty period should extend for several years, the exact time being dependent on the type of product involved and its application. The period must be long enough to allow the development of a valid field data base which will permit the practicable trade off between cost of

design changes and cost of repairs. This is the key to the "I" (improvement) in RIW. Only through failure analysis and possible redesign can improvements be made. The actual warranty length will depend on the usage factor, storage time, expected failure rate, maintenance concept, etc.

D. Termination of Warranty

The most economical approach for the USAF would be to renew the warranty prior to the expiration of the initial warranty period. Negotiation of the warranty renewal terms must be started prior the last year of the initial warranty period. This approach would:

1. Reduce the heavy salary and pension commitment by USAF for support personnel

2. Minimize the need to purchase organic maintenance training programs, maintenance handbooks, intermediate and depot level test equipment, etc.

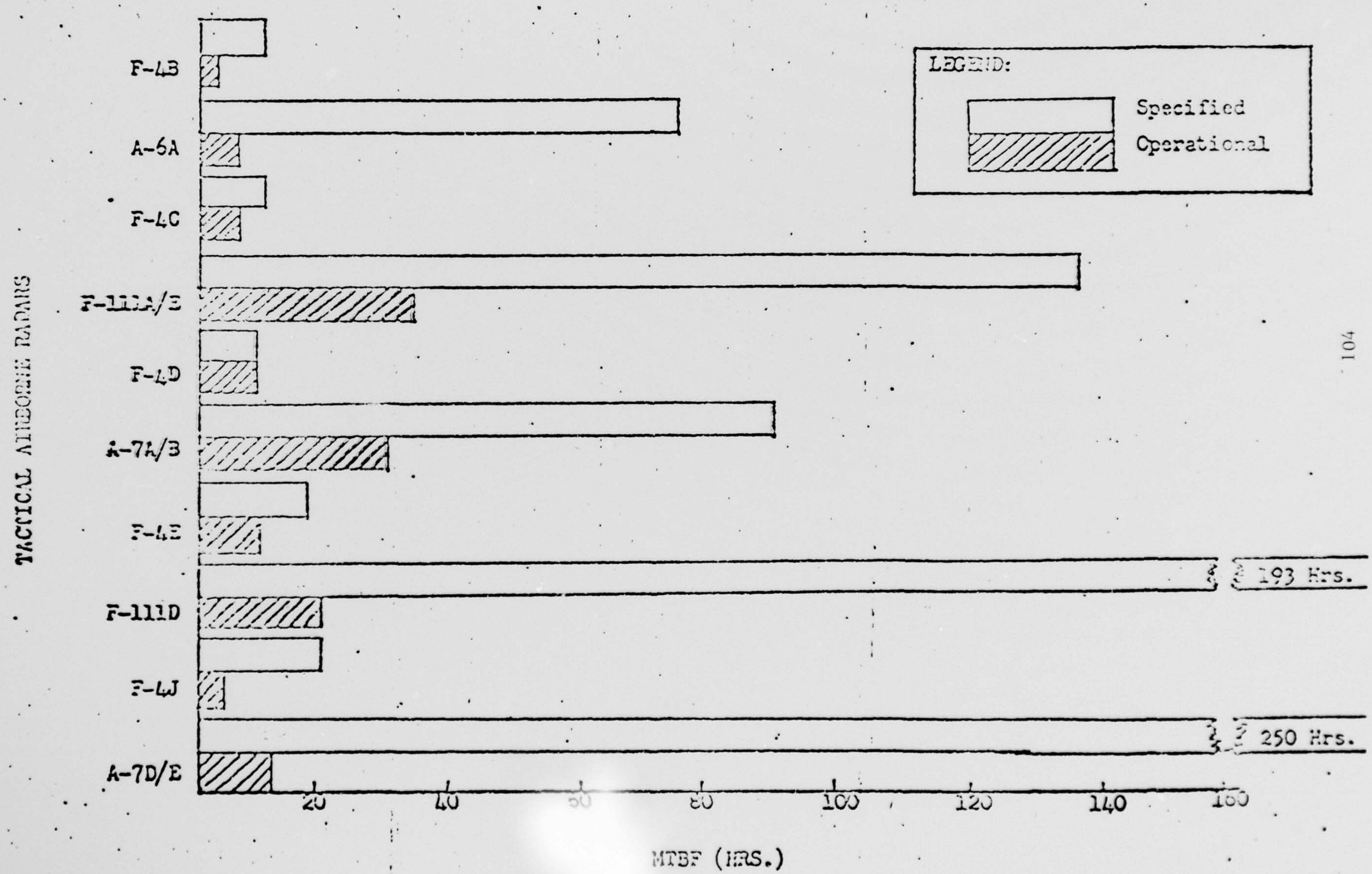
3. Insure continued maintenance by highly qualified, well trained and experienced contractor personnel.

4. Eliminate the need for spare parts cataloging, inventory pipelines and reduce spare LRU (Line Replacement Unit) requirements.

5. Have a gradual and manageable impact on present organic depot facilities and personnel since primarily newer systems would have RIW.

If the RIW program is terminated and organic maintenance implemented, then provisions should be made in the initial procurement for the orderly phasing-in of USAF maintenance.

WE SELDOM GET WHAT WE SPECIFY



II. RIW CONTRACTING BASIS:

A. Type of Contract

To provide the flexibility needed to procure the various DoD requirements, ASPR (3-401) has established a wide selection of contract types. At one extreme is the firm fixed price type which is used when there are reasonably definite design or specification requirements and the costs can reasonably be determined and the contractor can therefore accept full cost responsibility. At the other extreme is the cost plus fixed fee type which is used when the uncertainties are of such a magnitude that costs cannot be estimated with sufficient reasonableness to ensure an acceptable risk to the buyer and seller. In this case, the fee rather than price is fixed and the contractor's cost responsibility is minimized. ASPR (3-401) further states that when the risk is minimal or can be predicted with an acceptable degree of certainty, a firm fixed price contract is preferred. However, as the uncertainties become more significant, other fixed price or cost type contracts should be used to avoid placing too great a risk on the contractor.

It is within this framework that we must look for the appropriate contract type to be used for RIW contracting at various stages of equipment design development, production, and operational deployment.

1. RDT&E Design Phase

The design and development phase of any program which involves new technology or new applications of existing technology carries with it a significant amount of uncertainty. It has usually been the practice for the services to contract for this phase utilizing a cost reimbursable type of contract which is compatible with the ASPR. We have not generally experienced, nor do we envision that a change is justifiable in the basic method of contracting for research and development with the advent of RIW. In fact the uncertainties of equipment field performance, namely MTBF, during this phase mandates the use of cost reimbursement contracts.

2. Production Phase

We are also concerned with the method of contracting for the next phase -- Production. At this phase, without an RIW requirement, the design and specification requirements would have been finalized through adequate testing and the costs of production could be reasonably determined. However, the imposition of RIW on a fixed-price basis at this time introduces unknowns of considerable magnitude. Therefore the use of a form of cost-reimbursement contract continues to be necessary during the production phase. A fixed price RIW contract, in addition to being contrary to ASPR and DoD Directive 5000.1, is contrary to the application criteria set forth in the RIW Guidelines. These guidelines, among other things, that the field reliability, costs

to support the equipment, and potential for reliability growth will be reasonably predictable at the time the firm fixed price bid is made. Without field reliability data, the contractor cannot reasonably predict either the costs of support for the potential span of reliability growth. If he cannot reasonably predict these items, the rewards and risks to industry and the government cannot be balanced so that they are acceptable and equitable to both.

The OASD (I&L) memorandum, dated 16 September 1975 which was intended to clarify the guidelines, recognized and supported this position; however, enclosure I thereto seems to take an opposite view. This enclosure states that RIW can be applied to any new equipment, even if the design utilizes new technology and there is no previous experience. It implies that lack of actual experience can be overcome if there is adequate laboratory development time and testing. But, it goes on to note that considerable latitude exists in tailoring the terms and conditions to the uncertainties. Some examples are: (1) the reliability guarantee can be tailored, (2) turnaround time can be varied, (3) exclusions can be adjusted to fit the situation, and (4) the initial commitment can be limited to the initial production buy. In general, the greater the uncertainties, the less stringent would be the warranty terms. If it is conceded that this depth of tailoring is necessary due to uncertainties, a cost type contract for RIW would be more appropriate and we offer the following alternative for your consideration.

The design and development cost reimbursable contract would appropriately contain a RIW goal with positive incentives to motivate the contractor to apply resources to the area of equipment reliability. This should be followed by the purchase of a limited number of production units, either under an extension of the development contract or an initial production contract. We feel that a cost reimbursable type contract is most appropriate because it is during this field-test-before warranty phase that the contractor would be acquiring field operational data and making design improvements to enhance reliability. This "bridging" phase is essential because historically it has been proven that even the most stringent development testing in a lab environment is not a conclusive quantification of the operational field environment, nor can reliable and valid extrapolations be made from the former to the latter. In this way the unacceptable financial risk of premature cost commitments, is minimized during the period where there are many uncertainties, with firm RIW pricing to follow when appropriate data and experience have been completed.

B. Incentive Structure

DoD, in its incentive contracting guide, states that profit, generally, is the basic motivator of business; and, the profit motivator

is the essence of incentive contracting. However, industry and the government have had both good and bad experiences in the use of incentives. The unsuccessful ones can be attributed to complex incentive structures which were difficult to administer and were manipulated by the parties.

In spite of these bad experiences, we believe that multiple incentive cost reimbursable contracts - with proper weighting between cost incentives and demonstrated MTBF - can motivate contractors to make trade offs between increased design costs and lower support costs in favor of MTBF. Properly structured incentives under the cost type contract can achieve the same results as early fixed price RIW contracts with the proper balance of risk between the contractor and the government.

As incremental improvements in MTBF are more difficult to achieve, a curvilinear structure would theoretically be a more appropriate and motivational form of incentive. However, to date, there has been little, if any, use of the curvilinear incentive structure and, therefore, inadequate experience upon which to recommend it. Rather, we would recommend the more conventional linear structure for use with RIW.

C. REWARD/PENALTY RELATIONSHIP

The RIW clauses which we have observed to date in RFP and contracts are, from our perspective, using penalties rather than rewards, to motivate the contractor. We do not mean to imply that rewards by definition are not provided, but the probability of a contractor achieving them are slim particularly if the penalty/reward curve is skewed toward the former.

The following are representative examples that have appeared in recent hardware procurements:

1. Failure cause exclusions are very limited and the contractor must establish by "clear and convincing evidence" that any of the exclusions are applicable. Such matters as improper installation, operation or maintenance, as well as the normal range of events covered by force majeure are not covered. Further, the standard of proof required would be extremely difficult for the contractor to meet considering the fact that the equipment will have been operated solely under the control of military personnel.

2. Contractors are faced with accepting turn-around times (TAT) of 15 to 20 days for complex "black-boxes" or risk being non-responsive. Then, if they miss the TAT, they are assessed liquidated damages for each day in excess of the specified limit.

3. Basic to the RIW clause is the requirement for the contractor to repair or replace all units that fail (except for limited specific failure causes) even though caused by service personnel. Not only does this result in the contractor incurring expense to repair but it also directly influences (negatively) the operational MTBF and therefore the associated penalties.

4. The contractor is required to guarantee an initial MTBF with an escalating MTBF value each year through 48 months of warranty. In the event that the MTBF guarantee is not achieved, consignment units are to be supplied at no cost to the government. Delivery of these units is subject to liquidated damages of a specified percentage of unit price per day to a maximum of a specified high percentage of the unit price. This penalty is usually based upon a short delivery requirement both for in-production and out-of-production units. If the contractor fails to achieve the guaranteed MTBF over the life of warranty, the consignment units become the property of the government at no additional cost.

These clauses may not be as objectionable to a contractor if field operational test data were available on which to base his price, however, without this data they may be more likely to become penalties. Once again, if the implementation of RIW by fixed price contracting were delayed pending availability of field, operational test data, the probability of a more equitable balance between reward and penalty would be greater and hence more acceptable to the contractor.

III. MTBF REQUIREMENT *

A. Should the Government specify a minimum MTBF? (point, growth, or at all).

In considering a contractual requirement for RIW, the anticipated MTBF is the key ingredient in determining the selling price of the RIW. In a competitive procurement therefore, in order to insure that all competitors are striving for the same reliability target, it would seem desirable that the government specify a minimally acceptable MTBF goal together with a growth range (e.g., 800-1000 hours). It is recommended that this goal be set as described in the section of this report dealing with "Joint DoD/Industry Ombudsman". Briefly, the government would set a tentative value for the MTBF goal based on applicable historical

* Both MTBF (Mean Time Between Failures in operational hours) and MFHBF (Mean Flight Hour Between Failure) have been used to determine reliability. We are referring here only to MTBF because it is common practice to operate equipment at times other than during flight. Accordingly, hours in flight may represent only a fraction of total operation time. Further, the method of accurately computing MTBF must be specified, and the use of running time meters should be a requirement whenever technically feasible. The accuracy of any alternate system must be subject to contractor approval.

data, etc., and release this to the competitors prior to release of the RFP for their comment and tuning. The RFP MTBF goal would then reflect this value. Inclusion of a growth range would provide flexibility to the competitors in doing their tradeoffs of unit production cost and LCC.

Another possible reason for the government specifying a MTBF would be for guaranteed MTBF (GMTBF). Industry feels that the imposition of both RIW and GMTBF on the same contract places the contractor in double jeopardy and greatly multiplies the risks involved. Of the two plans for improvement in field reliability, the RIW is by far the most acceptable to industry. In no event, however, should both plans be imposed on the same contract.

If a GMTBF is to be used in lieu of a RIW, it is recommended that the value be set as follows:

B. What Kind of MTBF

It is recommended that the specified MTBF be set in the same fashion as described previously for setting the RIW price, i.e., an MTBF goal should be set prior to the design/development stage. Incentives should be applied to the meeting of that goal. The firm GMTBF value should however not be set until operational type testing has been performed on equipment similar to production hardware; and the final GMTBF value should be based on the results of those tests. The rationale is identical to that given for RIW in the section on "Timing of RIW Application".

Although the operational type of test is essential to the proper setting of the GMTBF value, MIL-STD-781 reliability growth testing should not be abandoned since it is an essential part of any development program aiming at a high field reliability. As noted elsewhere in this report, although MIL-STD-781 test results have not been directly correlatable with field reliability, they have proven to be a means of weeding out many failure modes during the development period, and therefore, funding and time should continue to be supplied for these tests.

C. When Should it be Applied? Successive Targets?

Industry feels that if a GMTBF is to be used, the successive target approach, coupled with a high degree of contractor freedom in introducing design changes during the successive measurement periods, is the most productive one for both industry and government.

For the government, it provides some of the same reliability growth features inherent in the RIW concept; while for industry it provides a realistic and attainable initial target, thus permitting time to discover some of the unknowns involved in extensive and varied field use of the product. At the same time the achievement of a higher final MTBF value will result because of the learning time than would be achieved if a point target only were involved.

D. Joint DoD/Industry Ombudsman

We believe that a joint DoD/Industry ombudsman group, although mutually beneficial in some situations, e.g., policy or regulation review, is not appropriate for the task of "scrubbing down" MTBF requirements in the solicitation.

The use of an "independent consultant" (i.e., not one of the competitors) raises questions of qualification, competency, and what might be called "responsibility to client" if the consultant were to be engaged by the government. Also, it must be recognized that such a consultant assumed no risk under a contractually binding commitment. For these reasons, we recommend against the use of such a consultant.

There are alternatives current available to the services which should effectively accomplish the same end.

For example, the Department of Defense Directive 4105.62, dated January 6, 1976 furnishes a mechanism for reviewing requirements within DoD and for utilization of industry input in arriving at the decision. Subparagraph III.D.2.h(2) provides for the establishment of a Review Board that, "Shall insure that specification requirements have been thoroughly examined and justified for the purpose of eliminating non-essential or unduly restrictive requirements and that the solicitation requirements have been correlated with the operational needs."

Subparagraph III.C.2.h.(5) establishes a requirement that each solicitation provide for industry feedback from prospective contractors prior to the proposal due date. Also, the services have implemented a prerelease of the RFP requirements for industry review and input.

We recommend the above methods in lieu of the ombudsman group as a means of making industry input available to the services for their use in arriving at a final decision. At the same time it does not have the drawback of potential conflict of interest that a joint group would have.

IV. FAILURE:

A. Definition

The key to verification of an operational MTBF is the definition of failure used to compute the MTBF. This definition must include what is counted as a failure and what is excluded as a failure. A failure is defined as "any departure from the required performance in excess of the allowable tolerances, defined in the equipment configuration item design and test specification due to its own internal failure."

1. Exclusions

The contractor should not be obligated to correct, replace, or propose ECP actions at no cost to the government with respect to any hardware item under RIW nonconformance, loss or damage by reason of:

(a) Fire
(b) Explosion
(c) Submersion
(d) Flood
(e) Aircraft (vehicle) crash
(f) Enemy action
(g) Seal broken on unit while outside contractor's control
(h) External physical damage caused by accidental or wilful mistreatment
(i) Internal physical damage caused by accompanying external physical damage due to mistreatment or to tampering by non-contractor personnel
(j) Act of God
(k) Induced failures. Failures of hardware items induced by malfunction or improper operation of outside (system interfacing) units
(l) Consequential/incidental damages
(m) Unverified failures (i.e., the item "retest okay")
(n) Improper installation/operation/or maintenance
(o) Having been designed or developed or produced by others than the warrantor.

Repair/replacement actions taken by the contractor with respect to hardware items damages by and/or subjected to these above-excluded circumstances/clauses/conditions should be compensated by an equitable adjustment in applicable contract provisions including but not limited to price.

ECPs prepared to affect design changes aimed at precluding future failures related to these excluded causes/circumstances/conditions and/or which have the effect of changing the design and/or environmental specifications under which the hardware item was initially procured, should, for the purposes of RIW, be considered as relating to exclusions and thus be subject to negotiation and equitable contract adjustment.

In RIW program management practice, there would be a presumption that all candidate hardware items returned during the RIW period would be covered under the warranty, and the contractor would be expected to proceed to take those expedited actions most advantageous to the government's operational status. However, if such actions were taken in good faith on hardware items ultimately determined, through contractor failure mode analyses, to be subject to any of the excluded conditions/causes/circumstances cited above, there should be no presumtpion of his non-entitlement to the equitable adjustment provisions of the contract.

However, the contractor must present evidence to substantiate an exclusion and the government must have a designated individual with the authority to approve or disapprove the exclusion. The contractor should have the right to place contractor personnel at any location at Government expense where there is evidence that O&M reporting is erroneous (66-1 system) or that conditions (set forth in Section IV.A) under which the contractor is not responsible may have existed but were not reported.

Those units returned to the contractor, which fall under exclusions, should be referred immediately to the ACO and PCO for resolution. Only those failures occurring subsequent to final acceptance should be included in the RIW Program. Only through such rigorous control can the manufacturer assure that proper maintenance is being conducted on his warranted item(s). The repair cost of excluded failures should be covered by a separate clause or contract.

All failed units returned to the contractor should be accompanied by a statement of failure mode, operational and test data, etc., completed accurately and comprehensively utilizing contractor recommended testing facilities, equipment and procedures.

The verification of failure should be performed by a method agreed to by both the government and the contractor. The use of built-in-test (BIT), based on past BIT capability, would rule this out as an acceptable method to both parties. The use of detailed acceptance test procedures and an intermediate or depot manufacturing tester would probably be the minimum test method for failure verification acceptable to both parties.

2. Degree of Control, Government vs. Contractor

Interface and authority/responsibility patterns between organic maintenance functions and warrantor must be clearly defined. The government must be prepared in this area to make hard decisions concerning a possible revamping of traditional organic maintenance and support functions now held closely by the services, in favor of an augmented role in these areas of the design authority - viz., the contractor. This is true because the contractor perceives his risk to be greater or less in direct proportion to the degree and extent of his involvement in field operations and logistics management activities. Also, because the field reliability/design loop is best closed by the mechanism of coherent contractor management of field service/design organization activities.

The warrantor should have complete visibility and requisite control over assets management (handling of hardware, recording and validation of failure data, fault mode analysis, pipeline spares management, access

to government records, etc.) during the field-test-before-warranty phase as well as during the long-term RIW phase production/spares contracts.

3. Timing, Responsibility Vesting

Turn-around time (TAT) for each warranted item should be agreed to by the government and industry preferably as a range or band of time (e.g., 21-30 days). The TAT "clock" (i.e., start of contractor responsibility) should start upon date of receipt of the warrantable asset(s) as verified by the ACO's representative, at the contractor's repair facility, also to be contractually designated.

Responsibility for control of the asset(s) should be considered to be transferred back to the government effective with turnover to the resident government inspection and acceptance authority at the contractor's repair facility. Shipments should be made F.O.B. contractor's plant on a Government Bill of Lading.

TAT performance should be assessed and measured over the whole warranty population and period - not on an individual return basis. Evaluation of TAT performance should be made on the basis of the average of all item returns to determine that such average TAT fell within the contractually established time band. Penalties for exceeding the upper limit of the TAT band should be assessed only if it can be conclusively established that the delay was caused by or attributable to gross failure, negligence or to the chronic lack of managerial diligence on the part of the contractor's managers. Assessment of liquidated damages in connection with TAT is unjustifiable in any case since this would result in double jeopardy in conjunction with requirements for consignment spares.

4. Retest O.K.

Excessive retest okay equipments are a problem to both the government (increased pipeline, low availability) and the contractor (cost of testing). Therefore, the government should be required to pay the contractor for each returned equipment that retests okay. The value should be large enough to compensate the contractor for the cost of testing and to encourage/force the government to perform adequate testing at the base level to reduce the number of retest okay returns.

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